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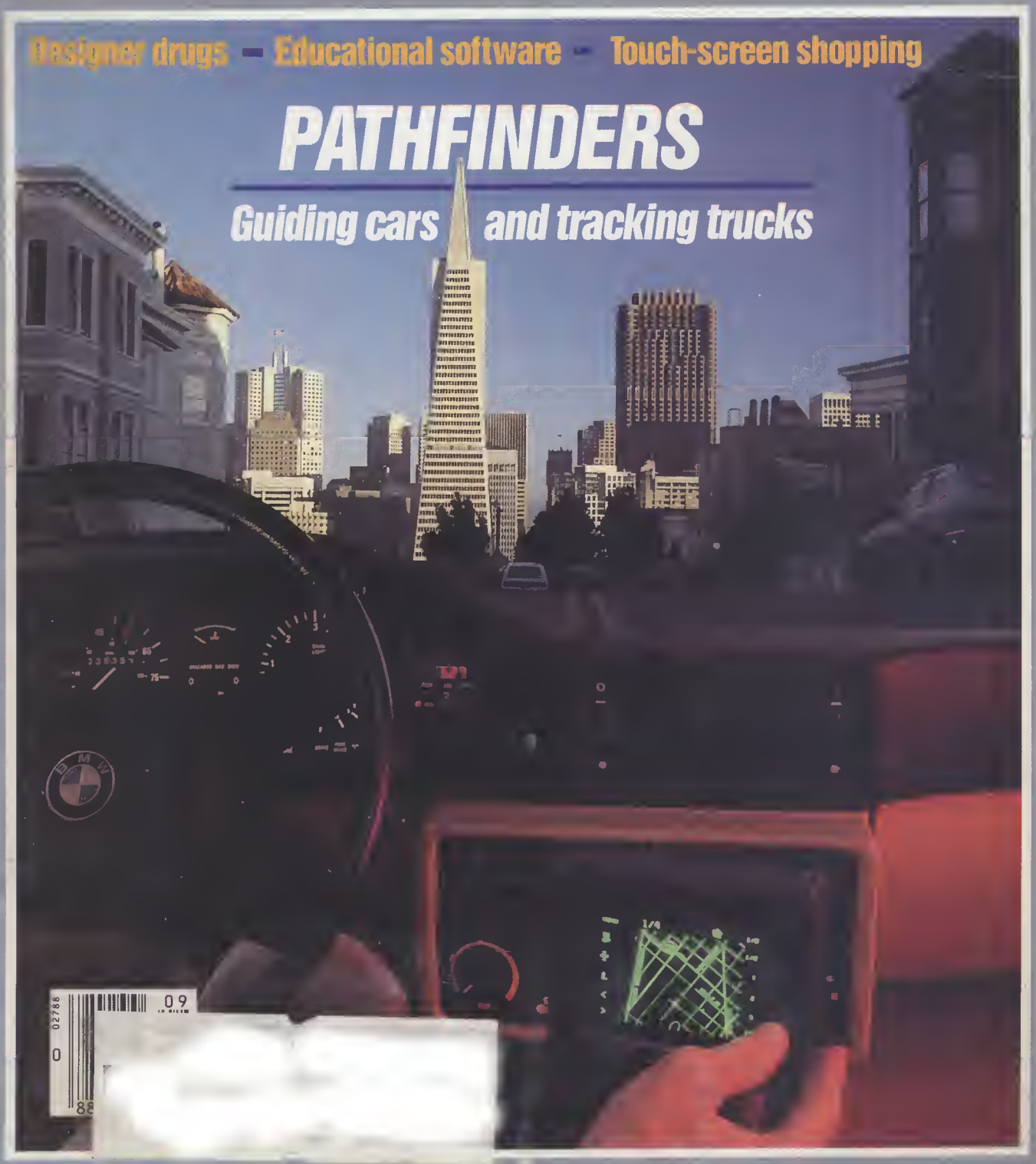

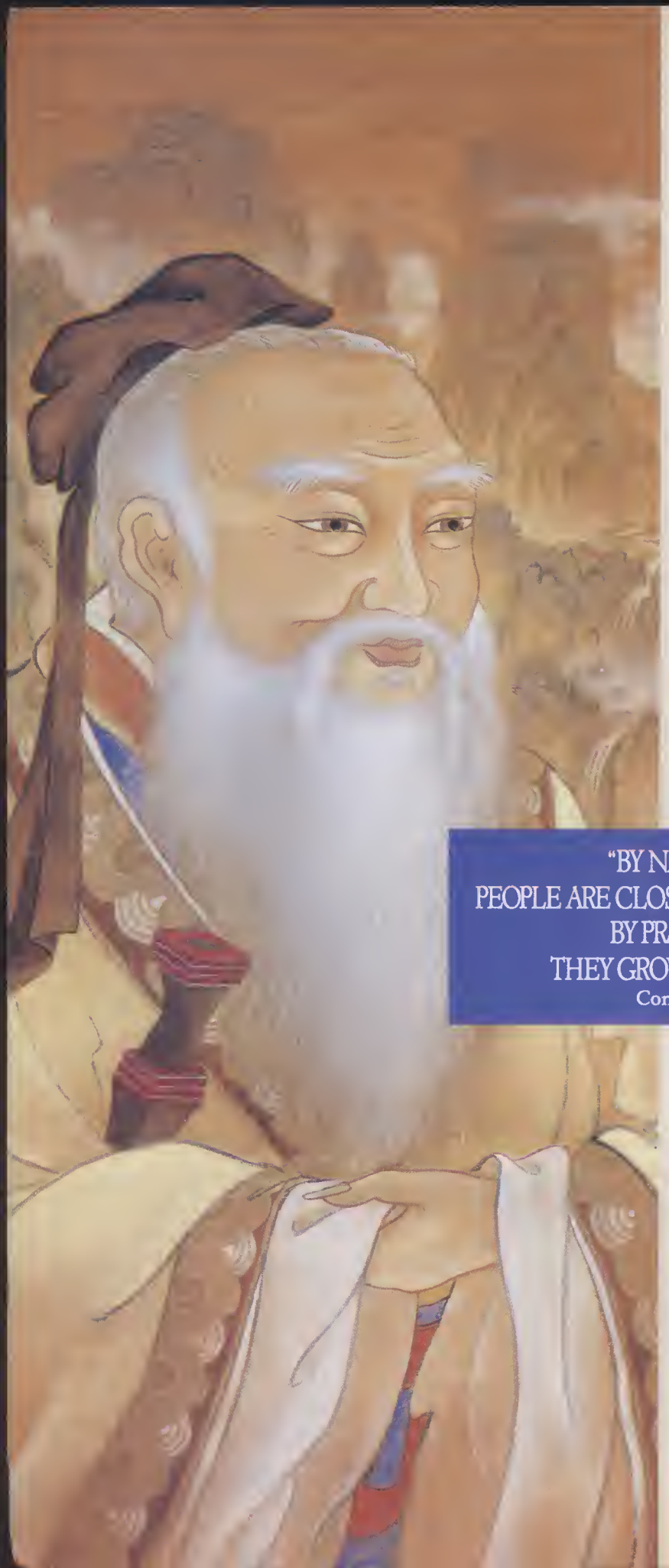

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SEPTEMBER 1986

high Technology

VOL. 6, NO. 9

18

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FEATURES

DEPARTMENTS

LES KANTUREK

Key to success in a fast-changing world: adaptability

Because technology is rapidly changing society, organizations of all kinds—from small businesses to whole nations—must prepare themselves for rapid adaptation in order to stay competitive.

The U.S. has much to learn from Japan in this area. Americans tend to think of the Japanese as unimaginative, copying technology developed elsewhere rather than creating it themselves. This perception has some historical validity, but it is a narrow and outdated view. To catch up with the Western world, the Japanese did borrow technology from elsewhere. But they methodically reshaped their institutions at the same time. "Visions of the future," for example, were worked out by government/industry teams to help Japan set priorities and formulate national programs.

The emphasis on adaptability continues in Japan. After catching up and even moving ahead in a variety of technologies, fundamental R&D is now needed to maintain leadership. So there's a strong national push for more basic research. As other Asian nations take advantage of lower wage rates to compete with Japan in industries ranging from steel and fasteners to VCRs and automobiles, the Japanese will need to develop new kinds of businesses. Another national program is encouraging a more entrepreneurial spirit in young people.

Japan's adaptability is also illustrated by its willingness to develop new disciplines as technology changes. In manufacturing, for example, knowledge of both machinery and electronics is becoming important. Thus "mechatronics," a combination of the two, is a growing field. Holonics, the study of independent but symbiotic biological systems, is the subject of one of Japan's nationally coordinated research programs, and it may spawn new concepts for electronic and mechanical systems. Meanwhile, American and European educational systems tend to be more rigid, with separate departments generally protecting their turf rather than forging links to explore new fields.

This systematic adaptation bodes well for Japan's future. It appears that the Japanese will find a way to respond even as more global competitors vie for its markets. Unfortunately, few signs of such national adaptation are apparent in the U.S. system. Hopefully, a new generation of voices better attuned to the needs of our times, in both the political and business arenas, will begin to gain America's attention.

Robert Haavind

highTechnology

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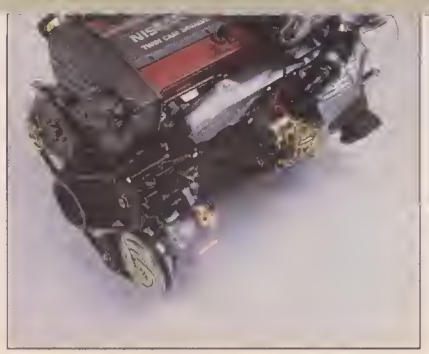
Paul Perkovic, Technical Marketing Mgr.
Software House
Cambridge, Mass.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110.



A turbocharger with a ceramic turbine boosts engine power in Nissan's 300ZX.

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LETTERS

Turbines for cars

I enjoyed your article "Little engines that can" (June 1986, p. 12). The present evolution of engines has contributed to smaller and more fuel-efficient engines, but at the expense of simplicity. Those of us who used to carry tools in the car to change the points no longer have that flexibility if the microprocessor-controlled ignition fails. With the increased use of sensors and emissions-control equipment, the contemporary driver is at the mercy of the manufacturer and service garages. Only time will tell if the life expectancy of these smaller, high-revving, more complex engines will be comparable to the old, simpler V8 and straight six.

An obvious route to longer engine life would be to use gas turbines. Since they have roughly a fifth the number of moving parts and half the weight of reciprocating piston engines, they are less complex. They are less fuel-efficient than reciprocating engines because they run at lower peak temperatures, but the use of ceramics will enable considerably higher operating temperatures for turbines. Nissan is already using a small ceramic turbocharger in some of its 300ZX sports cars.

Another obstacle to using turbines is that they "like to be used" at a constant rpm, and conventional automotive transmissions require the engine to constantly vary in speed and torque. However, a continuously variable transmission (CVT) would be an ideal mate for the gas turbine since it permits constant engine rpms. Both European and Japanese car manufacturers are presently developing CVTs.

Let's hope that the American car manufacturers do not cry for protection when the gas turbine is introduced by the Japanese, since Detroit appears to be more interested in marketing what they wish, rather than what may be in the best interest of the consumer—such as an engine with an extremely long life and a simply constructed car.

A turbocharger with a ceramic turbine boosts engine power in Nissan's 300ZX.

William Rynone
Annapolis, Md.

Whose space plane?

I read your article "Launching the aerospace plane" (July 1986, p. 46) and was much impressed because the technology could actually become a reality.

But the statement by Paul Czysz of McDonnell Douglas—that because any ascent-to-orbit aircraft will incorporate classified technology and thus will fall under export controls, a derated version will be constructed—was most distressing. In other words, after the American people have put billions of dollars into developing a new generation of aircraft, they will not gain the full economic return from their investment, even though a project of this sort has the potential to generate considerable revenue (by having commercial companies build and operate these aircraft).

I hope the aerospace plane becomes a stunning example of what this country can do when scientists and engineers are allowed to develop new technology, and not another example of political interference in technological development.

Mark Norris
Englewood, Colo.

Lost in the translation

Your readers who use translation software ("Machine translation poised for growth," June 1986, p. 53) should read the following text in clear measured tones to their voicewriters.

"Cap ten and my caftan," kept on crying the captain, "cap ten!" Of numbered caps cap ten suited the captain. He had numbered them as the numb bird landed. "Land dead ahead!" called out the mate to cawing from the numb bird. Would its gnaw tickle? It cawed, but it was caught on the carpet. "Correction!" the captain would carp pettily, "Your nautical law has no tickle. We've three types of wreck: surface, deeper, core. Sir, fuss deeper, weave, hear the screw's deep purr . . ."

If the voicewriter makes more than five or six errors in transcription (or about one per twenty words dictated), some careful examination of the voicewriting concept may be necessary. While it may seem that this text has been contrived to place a fairly high strain on such machines, the type of difficulties it presents are not only normal but inevitable. Similar ones are found in everyday spoken English, where not only isolated homonyms but the ordinary internal phonetics of words and phrases can create obstacles to sound and word recognition. In some foreign languages, particularly Chinese and other members of the Sino-Tibetan family, this problem is much more difficult than in English.

A few years ago there was a great deal of noise about computers replacing analog or human translators. This was before it was realized how difficult the problems of translating natural languages actually are. Now those companies involved in machine translation talk of working with, rather than replacing, the translator.

Alex Gross, Codirector
Cross-Cultural Research Projects
New York, N.Y.

A rose is a rose is a . . .

I read your Opinion "Business opportunity is entering a golden age" (July 1986, p. 4). I am afraid you have been visiting with Mr. Reagan in the Rose Garden.

R. W. Lillie
R. W. Lillie & Co.
Granada Hills, Cal.

Fourth-generation languages

In "Programming without tears" (April 1986, p. 38) you assert that 12,000 users at 3M use our product System 1032 4GL. Actually thousands use our earlier product, System 1022. 3M is in the process of converting to System 1032 4GL on VAX, but currently there are far fewer users. Both systems allow 3M's novice end users to get meaningful information without tying up the information systems department, as your article points out.

Paul Perkovic, Technical Marketing Mgr.
Software House
Cambridge, Mass.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110.

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NEC INTRODUCES WORLD'S FASTEST FLOATING-POINT SIGNAL PROCESSOR.

Our μPD77230 Advanced Signal Processor breaks the floating-point barrier in digital signal processing (DSP) with unprecedented speed and accuracy.

The new single-chip CMOS DSP races through 32-bit full floating-point arithmetic at 13.4 MFLOPS. It executes up to 6 concurrent operations, including multiply and accumulate, in a 150ns cycle.

With 32-bit floating-point precision, our advanced signal processor eliminates problems with round-off error, quantization noise, scaling, limit cycles and over/underflow. It is unique in offering a 55-bit multiplier result (8-bit exponent, 47-bit mantissa), with eight 55-bit registers, 47-bit ALU and barrel shifter.

In addition to its large internal memory blocks (512 × 32 × 2 data RAM, 2K × 32 program ROM and 1K × 32 data ROM), the 77230 provides external expansion up to 4K of program RAM and 8K of data RAM. Serial and parallel I/O also add flexibility. The serial interface allows cascading, links with codecs and AD converters while the parallel interface supports master- and slave-mode operations.

The 77230 is ideal for image processing, graphics workstations, telecom and other applications requiring high speed and high precision.

NUMBER 135

NEW ZEALAND GOES DIGITAL WITH NEW FOTS AND NEAX61.

Plans for a nationwide Integrated Digital Network (IDN) in New Zealand, where the telephone ownership rate is among the highest in the world, are rapidly taking shape.

The New Zealand Post Office selected NEC to supply state-of-the-art 140MB fiber optic transmission systems (FOTS) and digital switches that will bring the digital future clearly into view.

NEC will provide all the necessary optical terminal and repeater equipment for the fiber optic systems to be installed in links covering Wellington, Auckland, and other major cities.

NEC's 140MB FOTS provides high-quality communications paths equivalent to 1,920 telephone channels. High-performance optical devices enable long repeater span. It also features in-service system monitoring functions, low power consumption and compact size. A slim rack, measuring 2.75m(H) × 0.12m(W) × 0.225m(D), accommodates three terminal systems.

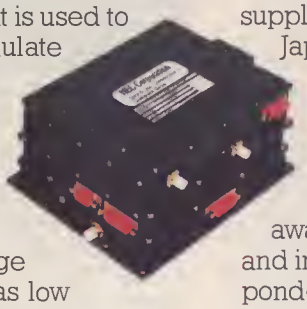
For the development of its ISDN, the New Zealand Post Office selected NEC's enhanced NEAX61 digital switching system with ISDN capability. Nearly 100 systems, including toll and international switches, are to be supplied within a five-year period.

NEAX61 digital switches with an aggregate total of 5 million lines are now in service in 36 countries.

NEC TRANSPONDERS SELECTED FOR INMARSAT-2.

NEC satellite transponders will play a key role in INMARSAT-2, the second generation of international maritime communications satellites.

NEC was recently awarded a contract from British Aerospace Public Limited Company to supply TT&C C-band transponders. This technology-intensive equipment is used to receive and demodulate telecommand signals, to transmit telemetry signals, and for ranging.



The transponder design will include various leading-edge technologies such as low noise amplifiers (Noise figure: 2.5dB), SAW filters to achieve excellent band-rejection performance (60dB min. ±2MHz from center frequency), threshold extension FM demodulation to achieve high sensitivity, and hybrid microwave ICs to minimize equipment size and weight, plus high-efficiency high-power amplifiers (RF output: 6W min.).

As one of the world's leading suppliers of satellite transponders, NEC has contributed to a number of international programs, supplying hundreds of advanced transponders for INTELSAT-IV, IV-A and VI series of communications satellites.

NEC has also integrated and supplied all the transponders for Japan's communications satellites, including the world's first two Ka-band satellites, and various TT&C (tracking, telemetry and command) transponders.

Additionally, NEC was awarded a contract to develop and integrate high reliability transponders for BS-3a and -3b, Japan's next generation of direct broadcasting satellites.

ALL-SOLID-STATE UHF TV TRANSMITTERS.

The latest 30kW UHF TV transmitter from NEC sets a new standard for high output power in all-solid-state design.

The 30kW transmitter incorporates many enhancements including high-performance exciters, powerful transistor power amplifiers, low-loss RF combiners and high-efficiency switching regulators.

The 1.2kW transistor power amplifier, utilizing reliable, high-power and high-gain (120W typical and 7dB min. at 860MHz) bipolar transistors which were developed in-house, features a remarkably reduced component count—only 1.7 times larger than the conventional 300W PA.

Compared to tube types, the new transmitter features greatly enhanced economy and reliability. Safety and maintainability are also improved, while power consumption is reduced by approximately half.

NEC's new all-solid-state UHF TV transmitter series includes 15kW, 10kW, 5kW and 3kW models. A 30kW system is already in satisfactory operation.

NEC

UPDATE

New tools for investors

Data distribution networks can give an investor or financial analyst instant access to stock quotes, but the constant flood of raw data is often bewildering. Some new financial hardware and software can help create order.

Signal, a receiver/decoder from Lotus Information Network Corp. in San Mateo, Cal., grabs the latest quotes on up to 250 selected stocks from the airwaves (they're broadcast over FM subcarriers in 13 major cities) and inputs them directly to an IBM PC or compatible. The system is designed to work with Lotus's spreadsheet programs Symphony or 1-2-3, which can sort incoming quotes into groups for quick analysis. Selling for $600 (plus roughly $110 a month for data from the main exchanges), Signal can be set to sound an alarm when a stock price reaches a certain level.

For more sophisticated analysis, Bristol Financial Services (Stamford, Conn.) has developed two programs especially for use with Signal. Window on Wall Street ($595–$1495), aimed at both the individual investor and the market professional, presents stock quotes in the form of continuously updated graphs, so trends can be more easily seen. The company's Insight package ($1495) provides complex features needed by traders, brokers, and analysts. For example, it can display a plot that monitors the ratio between the prices of two or more issues. It can also keep track of the value of an entire portfolio as new quotes come in.

Blue skies for the rotary

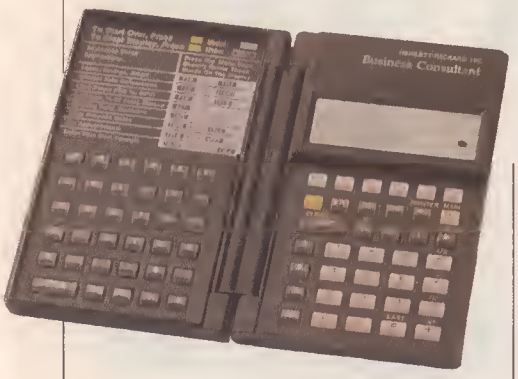
Rotary engines, which created a stir in the automotive world in the last decade, may do the same for air transport in the next. A NASA-sponsored joint project between John Deere Technologies International (Wood-Ridge, N.J.) and AVCO Lycoming (Williamsport, Pa.) aims to produce fast-starting rotaries for twin-engine business and commuter planes in the early 1990s.

John Deere technician assembles rotary test engine for planes. Delta-shaped rotor is attached directly to the drive shaft.

The rotary's promise for general aviation stems in part from the scarcity of fuel for piston-engined planes in certain parts of the world, including some U.S. airports. These planes, which predominate in general aviation, run on aviation gasoline, which resembles automobile gas. Rotary-engined planes, by contrast, could burn Jet A, the kerosene-derived fuel available at all airports for use by more expensive turbine-powered aircraft.

Rotary engines, in which combustion drives a rotating shaft instead of a piston, have other advantages over engines that traditionally power small aircraft, according to Robert E. Mount, executive program manager at Deere's Rotary Engine Division. These include lower fuel consumption, lower emissions, lighter weight, less noise, and—because of the rotary's minimal number of parts—higher reliability. The type of rotary under study, known as a stratified-charge engine, avoids the starting problems of other rotaries because ignition is begun by a pilot injector, which ensures combustion once the remainder of the fuel enters the chamber (via a separate injector).

The NASA contract specifies development of component technology for the rotary including a new electronic fuel injection system for more efficient combustion. The eventual goal: production in early 1990 of a 400-horsepower twin-rotor engine for general aviation (rotaries in Mazda cars produce about 120 hp).



HP calculator's alphabetical keyboard lets users store business formulas.

Business calculator does more than crunch numbers

In an age when manufacturers are producing powerful computers that fit on a user's lap, the prospects for the venerable calculator might seem bleak. Not so, says Hewlett-Packard, whose research indicates that many owners of lap-top machines opt for the convenience of calculators when tackling numeric tasks and that the market for "professional" calculators is growing 10–15% a year. Buoyed by these findings, HP recently introduced a sophisticated calculator for business users.

In addition to doing arithmetic, the $175 Business Consultant has an electronic appointment calendar and a text keyboard that lets users enter formulas into a 1.2-kilobyte RAM. For example, a car rental agency could store the formula "charge = miles × cost + insurance + rate," or a manufacturer could store "production rate = units ÷ days." When a formula is selected, the lowest line of the unit's four-line display labels the top row of keys to show which variables they control. The user simply fills in the numbers, and the calculator runs the formula.

HP, which hopes to use the Business Consultant to move beyond its stronghold in the scientific calculator market, offers a series of application books to assist users in areas such as real estate and banking adapt the calculator to their needs.

Color sense for industry

Manufacturers can produce more consistent surface colors with a new industrial color-matching system, claims Megatronics (Granville, Mich.), the computer specialty house that developed the product. The $25,000 system, called CURE (for Color Uniformity Recognition Equipment), is attracting the interest of automakers, furniture companies, fabric mills, and other manufacturers that face color control problems.

The eye of the color analyzer is a high-resolution charge-coupled device camera—a camera that sees with arrays of photosensitive cells instead of vacuum tubes. Each of the 256,000 cells transmits color readings to a microprocessor, which digitizes them and compares them with earlier samples or master-color data. When CURE notes a color difference, it calculates how much pigment should be added or subtracted.

CURE has several advantages over competing systems, which analyze color with spectrophotometers that break reflected xenon light into its component wavelengths and then compare wavelengths of various samples. Spectrophotometers can examine only areas an inch or so square, making it difficult to determine color uniformity on a large surface such as a car hood, and they must stay perpendicular to the sample. But CURE can check samples of any size and at any angle. Also, the bright flash of light needed by spectrophotometers wipes out the shadows that make a textured surface appear darker than a smooth one with the same pigment; as a result, such a system may indicate that, say, a car's upholstery matches its dashboard, even though a human observer sees a marked discrepancy. CURE can't be fooled this way, says Megatronics CEO Richard B. Maring, because it works in diffuse light.

Digital phones head for the hills

Although most of us take telephones for granted, the high cost of laying cable—roughly $1000 per mile in flat areas and much more in the mountains—keeps about a million remote U.S. households beyond the reach of the phone network. But a digital radio system now awaiting FCC approval could soon end their isolation.

The Ultraphone, developed by International Mobile Machines (Philadelphia), lets phone companies provide a two-way radio hookup between a central switching office and a subscriber's rooftop antenna. Digital transmission offers privacy (the signal can be encoded) and efficient spectrum use (four conversations can be interleaved onto each channel).

Ultraphone use will probably not become widespread, however, unless the FCC changes its rules governing access to the service's 450-megahertz frequencies. Right now, mobile phones have "primary" status on these channels; Ultraphone and any other fixed service that may arise must yield the airwaves if there's interference. But the Rural Electrification Administration and several associations representing phone companies have petitioned the FCC to give fixed phones primary access. Such a move would open the door to a huge potential market: "About 10% of the rural phone network is replaced every year for upgrading or maintenance," says analyst Michael J. How of Butcher & Singer (Philadelphia). "That's worth about $1 billion."

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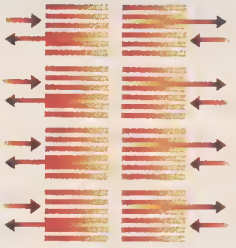

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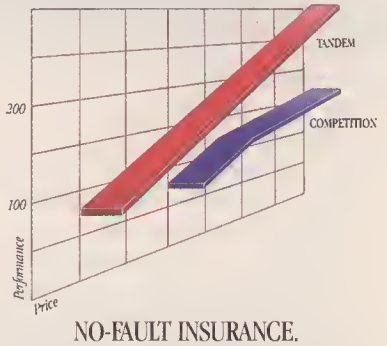

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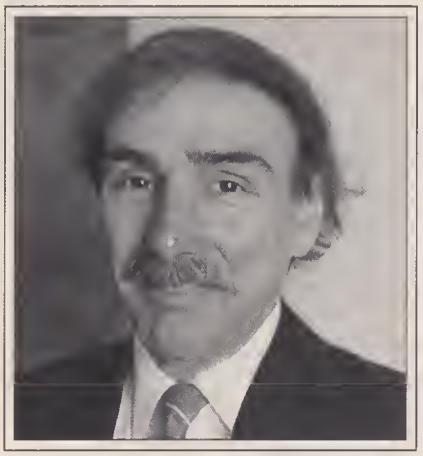


How to help the biotech business

John A. McMullen
Managing Principal, Cambridge Meridian Group

Biotechnology has the potential to be a cornerstone industry for the American economy. But despite a commanding early lead, it has had to run a regulatory obstacle course that has frequently bogged it down in lengthy and labyrinthine approval processes. Meanwhile, Japanese and European competitors have been steadily advancing. The question is: How can we best satisfy the environmental and ethical concerns that have arisen in the U.S. while maintaining leadership in this pivotal new industry?

One way is for the industry to assume a responsive and balanced position—taking the public's concerns seriously, and extensively analyzing plausible scenarios, but not trying to examine every complaint voiced by every critic. Such a strategy has already begun. The industry is evolving an "incremental hazards" approach to narrow the universe of imaginable risks down to a much smaller set that could feasibly arise in the circumstances at hand. This more manageable set of risks can then be evaluated under tightly controlled conditions before a commercial product is developed and released for general use.

Another way is to combine the diverse, and potent, resources of the American business community. The U.S. boasts not only biotechnology innovators but also giant pharmaceutical firms that have mastered their markets in head-to-head competition with European and Japanese companies. They possess vital competencies in clinical testing, regulatory know-how, efficient scale-up, marketing, and distribution. The power that could thus be marshaled has already been glimpsed in Lilly's success in bringing humulin (an improved form of insulin) to market so quickly. And with the acquisition of Hybritech, Lilly has expanded its agenda to include monoclonal antibody technology as well.

But regardless of the cleverness and strength of the industry's efforts, a supportive and coordinated regulatory environment must be established before it can achieve success. Government bodies like the Recombinant DNA Advisory Committee of the National Institutes of Health, the Agricultural Recombinant DNA Research Committee of the USDA, the outside advisory committees of the FDA, and the EPA's biotechnology advisory arm need to be streamlined and better coordinated. On matters affecting commercial development of biotechnology products, they must speak both with dispatch and a common regulatory voice.

An important step was taken in this direction in June with the issuance of new federal guidelines for minimizing turf conflicts among agencies as well as providing better traffic-control signals for specific product categories. The new rules have attracted both champions and critics—some allege, for example, that by adding new layers the program could actually cause additional delays—but the guidelines are still tentative and currently under congressional review.

Another positive step is the President's recent proposal for liberalizing the antitrust laws. This initiative would allow even greater cooperation among large companies, in R&D common to their strategic interests, than was permitted by the National Cooperative Research Act of 1984. This could be of great value in the commercialization of biotechnology; a large part of the research money previously cut from the federal budget could essentially be restored through joint research ventures funded by large pharmaceutical firms.

Three further steps are also needed:

• *Establishment of stiff penalties for improper use of American research.* Our firms spend vast sums to create a competitive edge in international markets, only too often to see their product or process illegally expropriated by infringers abroad. Legislation is needed that places the burden of proof upon local distributors to show that products obtained from foreign suppliers were not illicitly manufactured.

• *Removal of unnecessary market restrictions.* Changes are needed in the regulations that prevent U.S. firms from selling products in countries where they have been approved for sale simply because these products have not yet been approved by U.S. authorities. Such regulations handicap U.S. firms in international competition and eventually lead to a migration of manufacturing facilities and jobs overseas. Congress is now seriously debating appropriate remedies.

• *Enactment of limits to liability.* Because biotechnology firms deal in new and often controversial technology, they are likely to be harmed by the litigious tendencies sweeping the country. Even mature companies serving well-defined markets with well-known technology are finding themselves unable to afford the liability insurance they need in order to continue operating as they would like. The problem is far worse in industries like biotechnology, where insurance underwriters have no actuarial data on which to rely. But if passed, the Administration's recent legislative initiative to limit the financial consequences of liability suits will certainly provide an atmosphere that is more conducive to development of our biotechnology industry. □

Cambridge Meridian Group is a management consulting firm in Cambridge, Mass.

A. ZIMBERG

Symbolics:

LEADER OF THE A.I. PACK

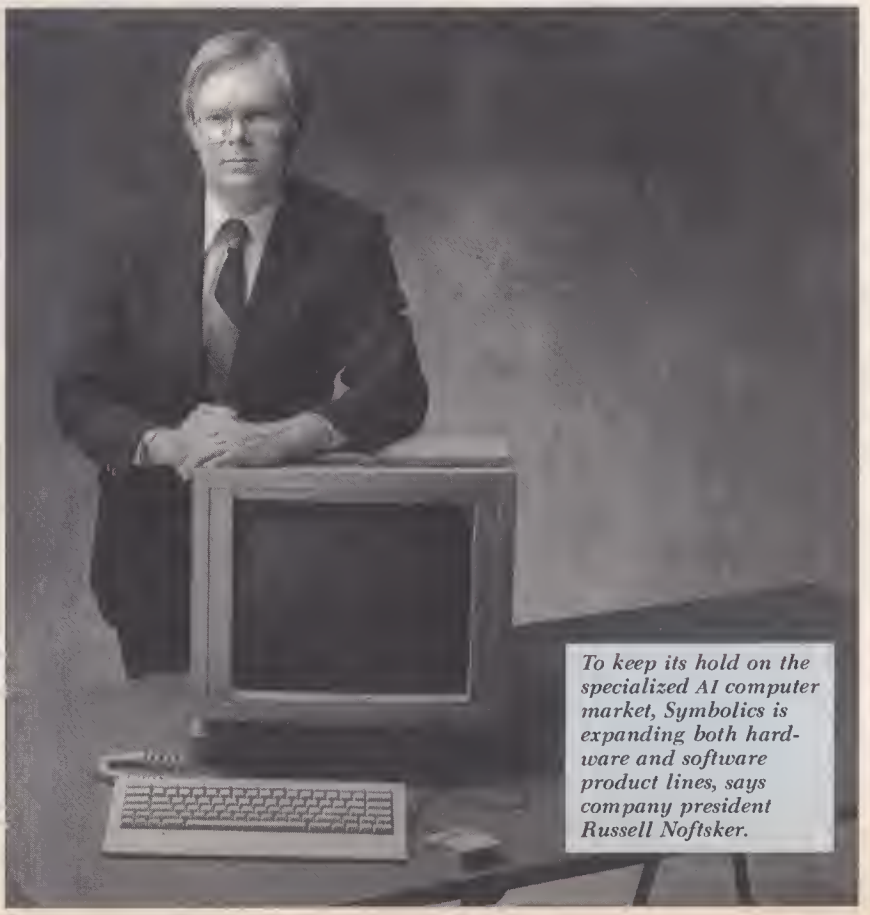
Despite the publicity artificial intelligence receives, profitable companies in the field are few and far between. That's what makes Symbolics (Concord, Mass.) all the more notable. The six-year-old manufacturer moved into the black in 1984, and this year, for the 12 months ended June 30, revenues are estimated by chairman and president Russell Noftsker to be $110 million, up from the previous year's total of $69 million. It has experienced steady growth through the worst recession in the computer industry, topping such heavyweight competitors as Texas Instruments and Xerox by capturing over half the market for specialized AI computers. However, Symbolics may soon be facing even stiffer competition, say industry analysts, from makers of lower-priced general-purpose computers adapted to run AI software.

Specialized AI computers—called symbolic processors because they manipulate logic and conceptual symbols in addition to numbers and text—carry hefty price tags, ranging from $50,000 to $200,000. But because they are tailored to AI's unconventional programming languages, Lisp and Prolog, they are the machines of choice for software development and should generate $200 million in sales this year, according to estimates by AI analyst Harvey Newquist of research firm DM Data (Scottsdale, Ariz.). Meanwhile, he observes, lower-priced, general-purpose computers may dominate in running—or, in AI parlance, "delivering"—already completed AI applications. Newquist projects that an additional $310 million will be spent this year on these machines, built by companies such as Digital Equipment, Apollo Computer, Sun Microsystems, and Tektronix.

Although in October Symbolics is bringing out a lower-cost addition to its own computer line (priced at $40,000 and with minimum orders of 20), the introduction is more a defensive action than an alternative to its midrange machine (which has a $50,000 starting price). "If we didn't have something that could be considered a delivery machine, some of our customers might have gone with other hardware vendors," says Noftsker, despite the limitations of their machines for software development. More than 90% of Symbolics' customers are still at the software development stage, he notes.

One of the company's main competitive strengths, according to analysts, is the help it can offer customers with its extensive line of software, including both AI and traditional scientific programming languages, graphics software, mathematical software, and networking software that links Symbolics computers to those from IBM and Digital Equipment. Software sales account for 10% of total revenues, but the proportion is rising, says Noftsker. The company is also partially funding more than a dozen additional products through joint development and marketing projects. For example, in an effort that may eventually help companies create AI programs to control and maintain industrial machinery—a market Noftsker believes will be important to Symbolics—the company invested in Natural Intelligence, a start-up developing a real-time monitoring system that will have links to Symbolics and possibly Apple computers. (Another start-up, Flavors Technology, has announced a similar product that links computers from Gould with AI computers from Lisp Machine, Inc.)

Symbolics' long-term success, however, may be tied to another project: transforming its computer's basic architecture into a microprocessor. Often referred to as "Lisp on a chip," such a microprocessor theoretically could be plugged into a traditional computer, turning it into a dual AI/general-purpose machine. Symbolics has pledged $9 million to the project, with another $7 million to be provided by Merrill Lynch Technology Ventures. Although Symbolics is keeping its timetable private, the chip may be more than two years from commercial avail-



To keep its hold on the specialized AI computer market, Symbolics is expanding both hardware and software product lines, says company president Russell Noftsker.

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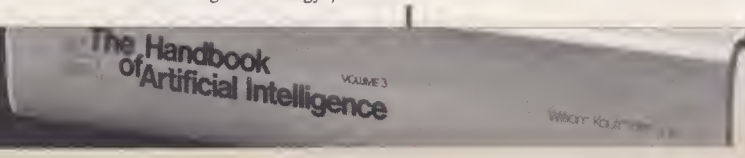

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The 15 chapters (5 per volume) include: the history, goals, and current areas of research activity; the key concept of "search"; research on "natural languages"; the design of programs that understand spoken language; applications-oriented AI research in science, medicine, and education; automatic programming; models of cognition; automatic deduction; vision and learning research; and, planning and problem solving.

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ability, speculates Jeffrey Canin, a computer analyst for Hambrecht & Quist (San Francisco). Meanwhile, competitor Texas Instruments is working on its own Lisp chip under a $6 million contract from the Defense Advanced Research Projects Agency. TI reports that it will deliver initial prototypes late this year, but the final version, estimates DM Data's Newquist, probably won't be commercially available until 1988 or 1989.

How Symbolics fares in this race may determine its fate. With its current delivery machine essentially a gesture, the company needs the Lisp chip to build a model priced low enough to compete with general-purpose computers. Otherwise, Symbolics may be unable to grow beyond the niche it already dominates for AI development computers. ***—Mary Jo Foley***

Integrated Genetics:
A THREE-STAGE WAR ON DISEASE

Not only does Integrated Genetics (Framingham, Mass.) occupy three niches in the biotechnology field—diagnostics, therapeutics, and testing for genetically transmitted diseases—it has also devised a timetable to funnel the revenues generated from one project into the next. With several new diagnostic products already set to follow its first (a salmonella test for the food industry, now on the market a year), the company can turn toward its medium-range projects: a variety of genetically engineered vaccines and therapeutic hormones. It can then tackle what it believes will become its major business in the 1990s, testing for genetic diseases.

The diagnostic part of Integrated Genetics' repertoire, which includes tests for gastrointestinal disease bacteria, hepatitis B, and the HTLV-I leukemia virus, have so far been "internally funded by venture capital and public stock offerings," says Patrick J. Connoy, VP of sales and marketing. (The four molecular biologists from MIT, Yale, Harvard Medical School, and Albert Einstein College of Medicine who founded the company in 1981 raised $7.4 million in venture capital, which was supplemented by $19 million more when the company went public.) The company bases its diagnostic products on DNA-probe technology, in which radioactively labeled pieces of DNA become homing devices as they link up with genetic material in certain bacteria and viruses, thus detecting its presence.

Although competition to develop DNA probes for human diagnosis is increasing, Integrated Genetics is one of the few companies to develop tests for the food industry as well, says Stelios Papadopoulos, biotechnology analyst for Donaldson Lufkin and Jenrette Securities (New York). The company's salmonella test, which can detect the microorganism in two days versus seven for conventional assays, is the only DNA probe–based test available for the food industry, despite a "sizable market," in Papadopoulos's estimation, with "regulatory hurdles that are significantly less than for the healthcare industry."

In therapeutics, Integrated Genetics is working in several areas, all with the help of corporate partners in the pharmaceutical industry. Its cardiovascular drug, the blood-clot dissolver known as tissue plasminogen activator (TPA), is currently undergoing clinical trials in the Far East conducted in conjunction with Toyobo and Daiichi Seiyaku Pharmaceutical of Japan. And its hepatitis B vaccine will soon be starting clinical trials conducted by Connaught Laboratories (Canada). Integrated Genetics is also making fertility hormones for humans (with trials set to begin next year) and animals and is developing substances known as blood cell growth factors designed to help patients regenerate new cells after suffering blood loss. All of the company's therapeutic products share an unconventional twist in manufacturing technology: cloned genes are grown in mammalian-tissue culture cells, rather than in more commonly used bacteria. Company scientists believe this may provide a biochemical milieu closer to that of humans and animals, thus aiding in the substance's effectiveness.

Integrated Genetics sees its greatest potential, however, in genetic-disease testing, which president and CEO Robert J. Carpenter (previously president of the Fenwal division of Baxter Travenol Laboratories) predicts will be "a major business 10 years from now." The company has established the nation's first genetic-disease reference laboratory, which it hopes will make genetic testing more accessible to doctors, and is itself producing tests for cystic fibrosis and Huntington's disease. Relatively few disease-causing genes have yet been identified, but it is often possible to predict such a gene's presence by detecting a nearby piece of DNA known as a marker. While the uncertainties inherent in using markers limit their usefulness to families or groups known to be at risk, advances in identifying specific disease genes should make large-scale screening increasingly feasible. "As we get closer to the genes that cause diseases," says Carpenter, "we can market products directly to genetic counseling units because the tests will be simpler." The company hopes to establish itself as a leader in what may eventually become disease screening for entire populations—a field that analyst Papadopoulos looks toward as "the next generation of biotechnology." ***—Ricki Lewis***

Plus Development:
SHRINKING DISK DRIVES

When the founders of Plus Development (Milpitas, Cal.) left the parent company, disk-drive maker Quantum, they weren't sure that it was even possible to make the products they had in mind: miniature computer disk drives that could be plugged—like ordinary circuit boards—into the expansion slots inside most personal computers. Not only did they find it was possible, but the three-year-old company spawned a market estimated today at $100 million and populated by nearly 50 competitors.

Hard disk drives squeezed onto circuit boards—or "cards," as small, PC-size boards are often called—aren't merely compact. They are also far easier to install than book-size versions that were previously the main options for supplementing PC memory. Plus's Hardcards eliminate additional circuit cards needed to control the larger drives and make it unnecessary either to remove one of the original floppy

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disk drives or add external connecting cables and power cords.

The devices represent a radical "repackaging of existing technology," maintains Plus president Stephen Berkley. Company engineers replaced several microchips with fewer, more complex ones, thereby reducing associated wiring, and also designed a miniature drive motor that cut the number of mechanical parts and cables by a third. These components now take only half the space of a conventional controller card, leaving room for a 3½-inch disk with a 10-megabyte (MB) capacity. But a Hardcard also had to run on the meager amount of power available in an expansion-slot socket and had to remain cool enough to keep from overheating the whole computer. With these design constraints eventually overcome (by using a low-power-consuming semiconductor technology), Plus sent the plans to Matsushita Kotobuki Electronics in Japan for manufacturing.

Hard disk cards have proven popular because they're so easy to install, says Jan Lewis, president of Palo Alto Research Group (Palo Alto, Cal.). Expensive dealer retrofits are unnecessary, she says, and "businesses moving up to more powerful computers can upgrade less sophisticated machines without any hassle" for use with hard disk–based software. For example, pharmaceutical company Squibb (Lawrenceville, N.J.) has used Hardcards to "extend the life of personal computers we've had for a long time," says Mike Giglio, who coordinates PC projects for the company. Squibb considered hard disk cards from several Plus competitors, he notes, such as Mountain Computer's Drivecard, which holds 20 MB of data. But because these large-capacity drives occupy 1½ expansion slots, says Giglio, "they take up too much space." Given the limited expansion area, he notes, "we have our PCs pretty well packed."

However, many other customers favor capacity over space. In June, faced with declining market share, Plus introduced its own 20-MB card, which it was finally able to fit into a single expansion slot by redesigning the drive motor and reducing the number of chips. This accomplishment sums up the young company's philosophy, contends Berkley. "Hardcard was not a technology-driven product," he says. "We saw what the market wanted and then built it."—*Jim Bartimo*

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KEEPING TABS ON CARS AND TRUCKS

In the old TV sitcom *Car 54, Where Are You?* dispatchers always had trouble finding the squad car driven by two earnest but ineffectual New York cops. It was good entertainment, but in real life, keeping track of a fleet of vehicles is a serious and costly business. Now, several emerging technologies promise to make life easier for fleet managers by providing continuously updated position readings for their cars and trucks, whether locally or anywhere in the country.

Tracking movement either by satellite or by ground-based navigation transmitters, location systems report a vehicle's exact position to a central dispatcher. Such systems permit dispatchers not only to monitor drivers but to give directions whenever and wherever they're needed. Alternatively, or in conjunction with centralized control, navigation systems in the vehicles themselves can guide the driver directly.

"If you're going to be part of a complex supply line, your transportation system has be be very dependable," says Peter Smith, senior vice-president for logistics and information resources at Leaseway Transportation, the Beachwood, Ohio, truck company that ranks among the top five U.S. motor carriers. "The trucking companies that can provide precise reporting are going to have a big competitive advantage."

The scheduling flexibility and responsiveness promised by location systems could be a boon to local vehicle fleets as well. Already, limited-range systems have been purchased by police departments, transit and taxi companies, waste-disposal firms, ready-mix concrete services, and an agricultural transporter (which tracks 140 trucks hauling sugar cane from fields to mill). They could also be used for such ubiquitous vehicles as parcel pick-up and delivery vans, ambulances, armored cars, and utility repair trucks. Another target is private vehicles—predominantly automobiles but also boats and off-road vehicles.

The market is still embryonic, but optimism abounds. One company alone, the West German electronic-equipment maker Standard Elektrik Lorenz (Stuttgart), predicts that sales of receivers for use with the U.S. military's satellite-based Global Positioning System will total $50–70 million within the next 15 years. In the United States, about 200,000 vehicles are expected to subscribe to privately owned satellite positioning services within the systems' first seven years of operation, according to Mobile Satellite (King of Prussia, Pa.), one of about a dozen U.S. companies proposing satellite vehicle location. Usage is expected to climb to half a million in 20 years, says John D. Kiesling, the company's president and chairman.

Position-finding technologies are categorized by their markets—they serve either locally based vehicle fleets or long-distance transporters. Vehicles of local fleets may be tracked either by self-contained dead-reckoning devices that outfit each car or truck with all the sensors, hardware, and software necessary to calculate its location, or by special receivers that pick up radio signals from the loran (long-range navigation) C network of beacons used extensively for marine and aeronautical navigation. In both cases, vehicle position data must be radioed from cars and trucks to their fleet's central terminal. Thus the range of two-way radios restricts coverage to smaller regions.

By contrast, a number of emerging position systems overcome geographic restrictions by relaying data via satellite between a fleet's terminal and its vehicles—wherever in the continental U.S. they happen to be. Satellite position-finding companies are therefore targeting interstate motor carriers.

The first of the satellite location companies, Geostar of

by Jeffrey Zygmont

Vehicle location systems, says Leaseway's Peter Smith, will lower operating costs, permit greater productivity, and result in better service to customers.

GORDON FISHER

Princeton, N.J., expects to offer its Link One limited service by early 1987, barring any launch delays by Arianespace. Link One will use one satellite to relay raw position data—plus digitally coded messages input by the driver—from a vehicle to Geostar's Princeton ground station, where map position calculations will be made by computer and transmitted to the vehicle's terminal. When the full system is operating (in 1989, according to current company estimates), radio-signal relays on two satellites will permit two-way data exchange between the truck and Geostar's base station. Meanwhile, however, only one-way data transmission—from vehicle to Geostar—is possible because of the overall load handled by the satellite.

Location systems can help vehicle fleets run smoother and with greater flexibility

Location data are therefore generated aboard the vehicle using a loran C receiver. Loran is a triangulation method based on pairs of ground transmitters that send radio pulses indicating the time that the pulses originated. (Loran C uses low-frequency pulses.) A "master" station emits a pulse that is relayed by a distant "slave" station. Thus both the original and the relayed pulse are received by the vehicle, enabling it to calculate the time it took a signal to travel from each beacon to the vehicle. The loran receiver then computes its distance from the master and slave, yielding a hyperbolic path along which the vehicle is located. A broadcast from a second master/slave combination gives a second hyperbolic plot; the intersection of the two represents the vehicle's location.

Because loran was originally set up by the U.S. Coast Guard

for off-shore use, positioning becomes less accurate with increasing distance—and diminished signal strength—on land. Cheryl Howarth, Geostar's manager of market development, says that even the company's high-powered loran receiver can fix the position of a vehicle only to within one or two miles. Nevertheless, many long-haul transporters believe this is close enough, as orders from seven motor carriers for more than 10,000 transmitters attest. The devices are priced at $2900 each, and Link One service will run $45 a month for one transmission an hour.

The map display of Motorola's locator gives dispatchers a ready view of vehicle position and status.

Geostar's full two-satellite system will locate vehicles to within 20 or 30 feet, says Howarth, because its satellite radio signals, originating from overhead, will be more powerful across the continental U.S.

Two-satellite location systems, classified by the Federal Communications Commission as radio determination satellite service, also use triangulation. The process starts at the base station, with an interrogation signal consisting of a digital signature code—the equivalent of a telephone number—that addresses the message to one or a group of vehicles, plus a digital notation indicating the time the interrogation was sent. One of the satellites relays the signal to the vehicle's transceiver. From there the signal is retransmitted to both satellites, which relay it back to the ground station. Recognizing its original time notation, the base-station computer calculates the time it took the vehicle's retransmission to reach the separate satellites. Since the satellites' position is known—in geosynchronous orbit they remain above fixed locations—the computer can then determine the vehicle's distance from each and pinpoint the vehicle. Finally, the computer consults its memory of digital map data to translate position coordinates into a real-world location and transmits it to the fleet terminal.

Because Geostar has been soliciting business from motor carriers for more than two years, its satellite navigation system is the most widely known. But it has some competition. Other companies seeking radio determination licenses from the FCC are MCCA American Radiodetermination (Jackson, Miss.), McCaw Space Technologies (Bellevue, Wash.), and Omninet (Los Angeles). Licensing is expected within a few months.

The FCC is also reviewing petitions from a second group, satellite companies that want to provide fleets and their dispatchers with rapid cross-country voice contact. Called mobile satellite service by the FCC, the concept is similar to Geostar in that it requires satellite links to transfer radio signals between trucks and terminal, but it calls for different frequency bands. Unlike the frequencies allocated for radio determination—which are cluttered with microwave interference, leaving only enough capacity for heavily coded position information and alphanumeric messages—the frequencies requested for mobile satellite systems are uncrowded enough to permit voice communication as well.

Locators "will revolutionize trucking," says Mobile Satellite's John D. Kiesling.

STEVEN GOLDBLATT

According to Kiesling of Mobile Satellite—the first of twelve such companies to petition the FCC—users will have the option of operating their own receiving stations, but high cost will restrict this to major fleets. Shared base stations for relaying position data to smaller system users (the way Geostar's Princeton central ground station does) will be operated by independent companies buying time on the satellite.

Kiesling predicts mobile satellite service will be fully operational about three years after final FCC approval, which he says is imminent—though the petitions were filed later than those for radio determination. In addition to Mobile Satellite, the petitioners are MCCA, McCaw, Omninet, Global Land Mobile Satellite (Port Arthur, Tex.), Globesat Express (Salt Lake City), Hughes Communications Mobile Satellite (El Segundo, Cal.), Mobile Satellite Service (Crossville, Tenn.), North American Satellite Services (New York), Satellite Mobile Telephone (New York), Skylink (Boulder, Colo.), and Wismer & Becker/Transit Communications (Pasadena, Cal.). Because the FCC intends to approve only one system operator, says Kiesling, the front-running petitioners hope to form a consortium that would own the system jointly. Although no one is stating publicly which companies might be included, the four most active petitioners—Mobile Satellite, Hughes, McCaw, and Skylink—will probably form the nucleus.

So far, however, Geostar pretty much has the satellite vehicle-location field to itself. The company's competitors are more interested in using satellites for message services between trucks and terminals, reports David Arthur, Omninet's vice-president of business development. He says simple transmission of digitally encoded messages is less costly

than location by radio determination, since is does not require calculations by powerful and expensive ground-station computers. With a keyboard in a truck permitting drivers to send messages, plus a decoder for reading alphanumeric messages, a fleet gains a vital communication link, he says. Drivers can use the system to call in at regular intervals, while the terminal can send instructions on, say, last-minute pickups. As an interim service similar to Geostar's Link One, Omninet will have a one-way, terminal-to-truck message system in operation next year. Already, says Arthur, his company has orders for more than 10,000 Omnitrac receivers for trucks, priced at $3000–$3500 each.

Omninet plans full two-way message service by mid-1988, though some limited truck-to-terminal service may be added earlier. Even with its full satellite system, however, Omninet will not provide position data; the cost of the necessary ground-station computer facility is too great, says Arthur. Instead, he proposes, each vehicle can use a Global Positioning System (GPS) receiver to compute location coordinates, which can then be relayed to the ground station automatically via the satellite message channel.

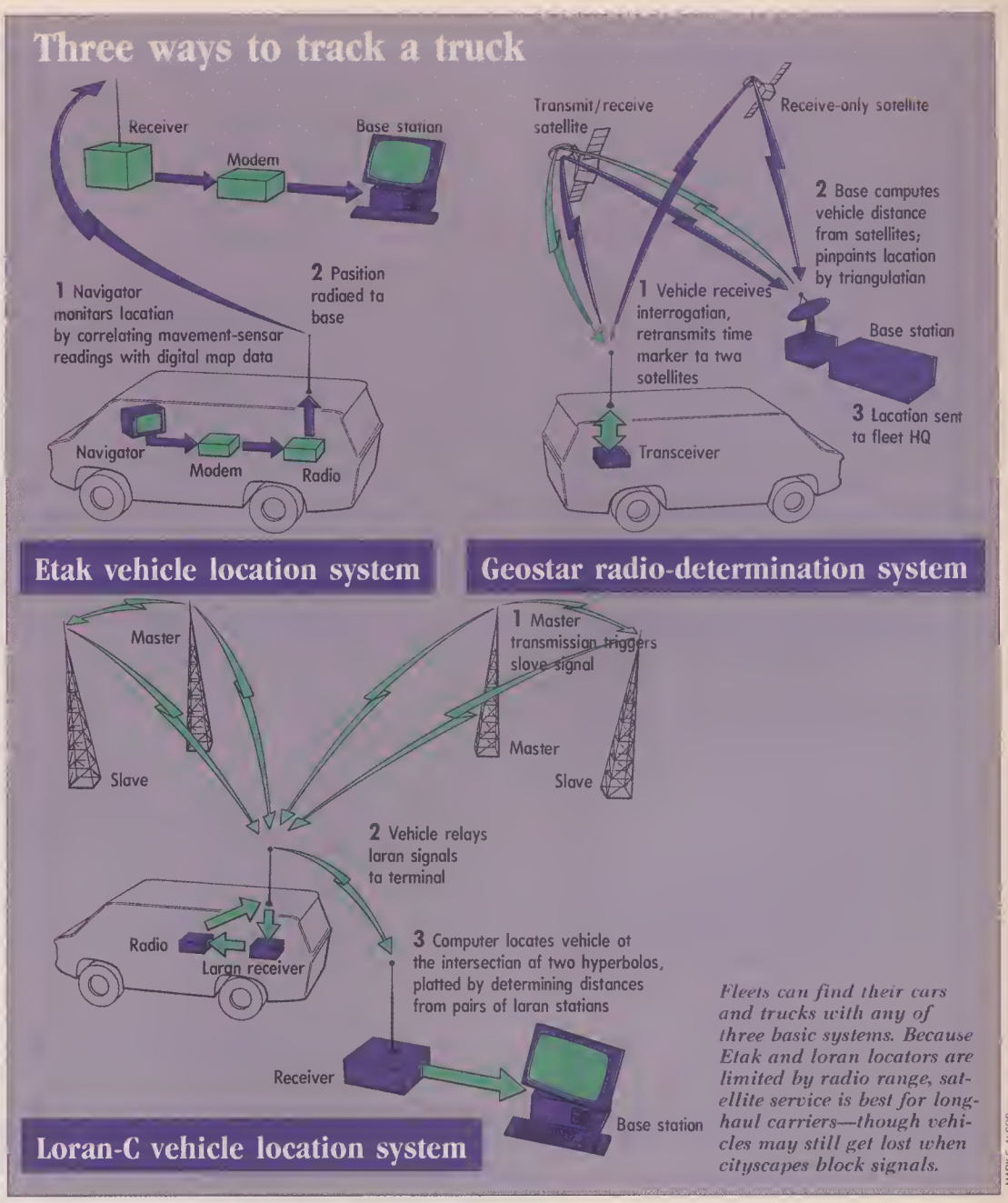
The problem with this approach is that the military satellite system is still in its early phase of implementation. With only seven orbiting satellites aloft, position finding is possible for just three to four hours a day, when enough satellites are visible at any given ground location. Therefore Rockwell's Navcore I, for example—a $17,000 civilian GPS receiver—is used primarily by land surveyors in remote locations, who do not need continuous updates. Eventually, however, a constellation of 18 GPS satellites will cover the globe with digital radio pulses. With its own internal clock to time the travel of satellite signals, a GPS receiver on a vehicle will be able to pull in transmissions from at least three satellites in order to triangulate its position. GPS will provide civilian position accuracy to within 200 meters.

A number of companies, including Rockwell and Texas Instruments, are already developing GPS receivers for motor vehicles and other land mobile markets. West Germany's Standard Elektrik Lorenz, an ITT subsidiary, plans by early 1987 to have preproduction models of a GPS receiver the size of a car radio. The company expects that the receiver's initial price of about $3000 will drop as the market picks up.

While satellite services jockey for the emerging vehicle location market in long-haul transport, two other technologies—dead reckoning (inertial navigation) and loran—are looking for niches among local fleets. Within urban areas especially, accuracy needs to be greater than that initially promised by satellite locators. And even though Geostar's eventual 20- to 30-foot accuracy will be sufficient, tall buildings are expected to cause troublesome signal interference.

Dead reckoning eliminates this problem because it uses on-board systems that calculate position without reliance on exterior radio signals. Dead reckoning systems have been demonstrated by a number of companies, including Honda (Tokyo), the automotive electronics giant Robert Bosch (Stuttgart,

Three ways to track a truck



Fleets can find their cars and trucks with any of three basic systems. Because Etak and loran locators are limited by radio range, satellite service is best for long-haul carriers—though vehicles may still get lost when cityscapes block signals.

MARK E. ALSOP

Steering motorists right

In addition to their commercial uses, dead reckoning navigation systems are expected to appeal to private automobile owners. So far, however, the only system to test the market is the Navigator from Etak (Menlo Park, Cal.). Since last fall it has been sold to about 1000 car owners in California; nationwide sales are scheduled to begin phasing in late this year, as Etak expands its map database.

A 4½-inch-diagonal video screen attached to the car's dashboard displays a continuously updated road map with the car's position marked prominently in the center. The map display turns when the vehicle changes direction, so that the top of the map display always reflects the view through the windshield. Drivers can zoom in for closer detail, including road names, or zoom out for a full view of an entire metropolitan area. They may also enter their destination, which is displayed by a flashing symbol on the video map. Etak is even talking about adding features like a restaurant index to each map cassette, promising quicker relief from hunger pangs on the road.

The navigator developed by Blaupunkt-Werke, a division of Robert Bosch (Stuttgart, West Germany), goes a step farther than Etak's; it actually guides motorists to their destinations. From a printed directory of building addresses, the driver enters a destination code. Calculating the best route, Bosch's Electronic Traffic Pilot directs the driver to turn by lighting direction arrows on the system's liquid crystal display. If a turn is missed, directions are recalculated automatically. Like Etak, the system uses "augmented dead reckoning," which correlates vehicle motion data with digital maps. Unlike Etak, it does not provide a map display for the motorist.

In addition to visual indicators, the Bosch system directs the driver with a voice synthesizer. Prompts such as *Please turn left at the next corner* or *Stay in the right lane* are "an important safety feature, especially when the driver is in heavy traffic and cannot take his eyes from the road," says Blaupunkt engineer Otmar Pilsak.

General Motors recently purchased stock warrants entitling it to 10% of Etak, thereby gaining exclusive rights to the system among North American automakers. Meanwhile, Etak will continue to sell the Navigator as an add-on, and may license its technology in foreign markets. But carmakers aren't jumping into navigation. John Moretti, body electronics program manager of Delco Electronics (a GM subsidiary), says GM won't offer a navigator until at least 1990. Because GM wants all components to be integrated into the body design, says Moretti, the car most likely to carry the Etak system first is the Chevrolet Corvette, being redesigned for 1989 with a video display screen built in.

Current market trends favor electronic information features, and demand for highly equipped, upscale cars is increasing, says T. K. Lakshmanan, who in 1985 compiled a study on the automotive electronics market for the New York market research firm Frost & Sullivan.

If these trends prevail, he says, the automotive market for navigators could reach $100 million by 1990, when a wider selection of products will be available. But advances in technology, plus increased competition, must first reduce prices significantly.

That may be happening already: the English electronics company Plessey Radio Systems has developed a cigar box–size dead reckoner priced at only about $700, notes Lakshmanan. And the automotive supplier VDO Adolf Schindling (Schwalbach, West Germany) offers a simplified dead reckoner for only $400. Outwardly, the VDO Citypilot has much less technological finesse than Etak's Navigator—it requires drivers to use a lightpen to enter starting-location and destination bar codes from a book of specially coded maps. However, the low price might attract users who get lost only occasionally.

West Germany), and the auto supplier VDO Adolf Schindling (Schwalback, West Germany). But so far, the only commercially available inertial system comes from Etak (Menlo Park, Cal.). Sold in California since last year, Etak's Navigator has been aimed at luxury and commercial passenger car owners. About 1000 of them have already paid the "under-$2000" price for Etak's dashboard-mounted video display terminal, which—when coupled with distance and direction sensors, a microprocessor with the computational capacity of an IBM PC, and a cassette database containing digitized road maps—shows a continuously updated map display with the car's position in the center.

Distance traveled is measured by sensors in the right and left wheels of the vehicle's nondriven axle, and direction changes are read by an electronic compass. These raw data are augmented with the system's map database: the microprocessor correlates the vehicle's motion with the stored knowledge of the street system, rendering a calculation of the vehicle's position relative to its starting point. The display is updated every second, causing the map to scroll over the screen. In addition, by accessing the database's menu-driven index of street addresses, a driver may enter his or her destination and then see it indicated by a flashing symbol on the map. Etak says its augmented dead reckoning is accurate to 50 feet.

For fleets, the next step is to relay the location data to the dispatcher. By the end of this year, Etak plans to offer its Vehicle Locator, a multiple-vehicle finder that consists of a dead reckoner with a modem added. The modem feeds position information to the vehicle's standard two-way radio, which relays it continuously to the fleet's base station, where it is decoded and displayed on a computer-terminal map along with the position of other vehicles in the fleet. What's more, dispatchers can transmit messages, which appear on the screen of the receiving vehicle. Another Etak product under development, the Dispatch Manager, is a computerized workstation allowing dispatchers to plot individual vehicle routes and to give drivers either printed route maps or electronic versions on cartridges.

Meanwhile, Motorola (Schaumburg, Ill.) is offering its Automatic Vehicle Location system—a loran-based regional location system—and II Morrow (pronounced "tomorrow") of Salem, Ore., is selling a similar product called the Vehicle Tracking System. With both systems a loran receiver costing about $2000 is required for each vehicle. Motorola's base station (to receive and process position coordinates) runs between $50,000 and $75,000, while II Morrow's sells for about $25,000. Motorola has sold about a dozen of its locators in just over a year, and II Morrow reports about 20 sales within the same period.

Because loran beacons are concentrated on the coast, coverage is limited. Motorola's system, for example, can be set up for state-size networks in only 75% of the continental United States. In 1987, however, the Coast Guard and the Federal Aviation Administration are scheduled to begin extending loran coverage into the midcontinental alley that runs approximately south from the Dakotas. Though intended primarily for aircraft, the extended loran sig-

CHRISTOPHER SPRINGMAN

RON KIMBALL

Top: Etak VP Stanley Honey shows a map display designed to keep drivers on course. Bottom: Using a loran system in Stockton, Cal., a bus driver sends a status report that then appears on the dispatch screen.

nals will also be available for vehicle location services.

The Japanese automaker Nissan (Tokyo) has also developed a loran-based system, targeted at the parcel delivery business, which routinely sends drivers on irregular, unfamiliar routes. With its Delivery Navigation System, demonstrated early last year, each driver starts the day with a floppy disk precoded by the system's master computer with the day's delivery list, delivery sequence, and local maps covering the route. In the guidance mode, the truck's location is determined with a loran receiver and shown on the color video map display inside the cab. So far Nissan hasn't announced any system sales.

Despite the feasibility of on-board navigation systems for drivers, delivery outfits seem to be leaning more toward location-reporting systems for their dispatchers. "We're not ready to spend $1500 per truck just to tell a driver how to get around the city," says Leaseway's Smith. Of course, the question of just what the motor carrier industry will use won't be settled until all types of location systems—satellite, dead reckoning, and loran—are available and tested. But early indications point to combinations of technologies that exploit the best features of each.

For instance, II Morrow is preparing to use Geostar transmitters to provide a long-distance link for its loran location system, says Laurence Cortland, the engineer responsible for the Vehicle Tracking System. The combination of dead reckoning and radio navigation is also likely, especially in areas with radio interference. II Morrow is bidding on a system for a New York utility company that needs inertial location capability when its trucks venture into Manhattan, where the canyon effect wipes out loran coverage.

"We're looking at several systems," says Leaseway's Smith, summing up the attitude of commercial fleet operators. Although Leaseway has ordered 100 Link One units from Geostar, the door remains open. Smith says he could use location services for about 5000 of the company's 20,000 trucks. But he is waiting for more results before committing the company to particular technologies or suppliers. □

Jeffrey Zygmont is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 69.*

AUTOMATED

Automated teller machines (ATMs), which quickly process many of the transactions once handled solely by human tellers, have become ubiquitous in recent years. Now, close cousins of the ATMs—in-store marketing systems—are beginning to appear in locations such as retail stores, hotels, and airports. With these systems, consumers can buy theater tickets, watch product demonstrations, purchase mail-order items, or browse through a store's daily specials. Major retailers and other corporations hope that the computerized units will improve their marketing effectiveness and generate greater sales.

Early electronic in-store systems employed simple display terminals that did little more than scroll through canned information, sometimes permitting limited customer interaction. New versions add power by combining different media; for example, full-motion video and still images stored on videodiscs can be used with dynamic computer graphics retained on magnetic disks. Current systems also use powerful microcomputers and sometimes incorporate modems to link them via telephone lines to a central controlling site.

These hardware components are usually housed in a video game–like kiosk, although tabletop enclosures and other designs are also available. Typically, the user selects items from the system's database by using either a rugged Mylar-sheathed keyboard or a touch-sensitive monitor screen. While there is usually no charge for using an in-store system, a consumer must have a valid credit card for transactions such as purchasing a travel ticket.

The new technology comes at a time when stores are under growing pressure to stimulate sales. The average yearly growth in retail sales from 1985 to 1990 will be only 2.3%, according to Touche Ross (San Francisco), a far cry from the 8% annual growth posted from 1980 to 1984. The installed base of in-store systems in the U.S. will grow from the present level of 1200 terminals to 50,000 by 1990 and could generate $5–10 billion in yearly sales, predicts Thomas R. Rauh, national services director for retail consulting at Touche Ross.

In-store marketing systems "are one of the biggest growth areas in electronic interactive services," says Martin Lane, director of videotex planning for Link Resources (New York), a market research firm. More than 60 North American corporations, including IBM, Sony, AT&T, and NCR, have developed full systems and components to meet the anticipated demand.

Sharon Nardini, a manager of retail point-of-sale systems for AT&T, predicts that in high-density markets, "specialty stores will evolve into combination stores consisting of low-square-footage brick and mortar premises and electronic kiosks that market a broad range of warehouse goods too numerous to stock in the downsize store." In less densely populated areas, she says, some retailers may turn to electronic marketing terminals exclusively to retain a cost-effective presence.

The application of the systems is as varied as the businesses that employ them. Sears Roebuck (Chicago) is using a videodisc and computer graphics system to help consumers select the correct window drapery products for their needs. Customers can examine more than 14,000 fabrics according to color, type of room, and other variables. Simpsons (Toronto) is using an in-store system to promote applications for the department store's own credit card. The data collected from credit card applicants, in turn, will improve the retailer's market research.

The Buick Division of General Motors (Flint, Mich.) employs in-store marketing systems both on the automobile show circuit and at dealers' showrooms. At shows, the Electronic Product Information Center (EPIC) systems collect information about prospective customers, which is forwarded to the company's telemarketing department for follow-up. The showroom versions do everything from displaying videos of different models to accepting orders for specifically configured cars. Customers can even use the systems to track the status of their ordered cars on the assembly line. Salespeople, meanwhile, use the system to keep informed about new models or changes to the existing line. Buick has installed more than 300 of these systems in showrooms, and plans to install 500 more.

Several catalog and retail firms are also evaluating the use of electronic kiosks for direct marketing. Among them are the Electronistore system from R. R. Donnelley and Sons (Chicago) and The Shopping Machine from Comp-u-Store International (Stamford, Conn.). Typically, the day's orders are either collected locally each evening or sent via an attached modem and communications link directly to the mail-order firm's headquarters for filling.

Even banks are employing in-store systems to offset some shortcomings of their ATMs. By reducing the contact between bank personnel and customers, ATMs make it harder for financial institutions to promote credit and other services. The Bank of Montreal has been testing two different in-store systems to market financial services to customers waiting to conduct ATM transactions.

Many of the new applications for in-store systems depend heavily on the use

by Paul Hurly

RETAIL

To increase sales, stores are turning to computerized marketing systems

PHOTOGRAPHS BY ANDREW SACKS/BLACK STAR

Buick *Installed in dealer showrooms, the Electronic Product Information Center (EPIC) lets customers examine features of different car models, see how different options affect the selling price, and compare the costs of buying versus leasing. After ordering a car, the customer can track its progress through the assembly line.*

PHOTOGRAPHS BY RAY ELLIS

Amtech *Each Express Shop USA kiosk contains two video screens and occupies just 40 square feet of space. Currently installed at three JFK International Airport terminals, the systems carry 92 upscale products, which customers can order directly through the kiosk. Each unit's computer is linked to Amtech's New Jersey warehouse and shipping facility.*

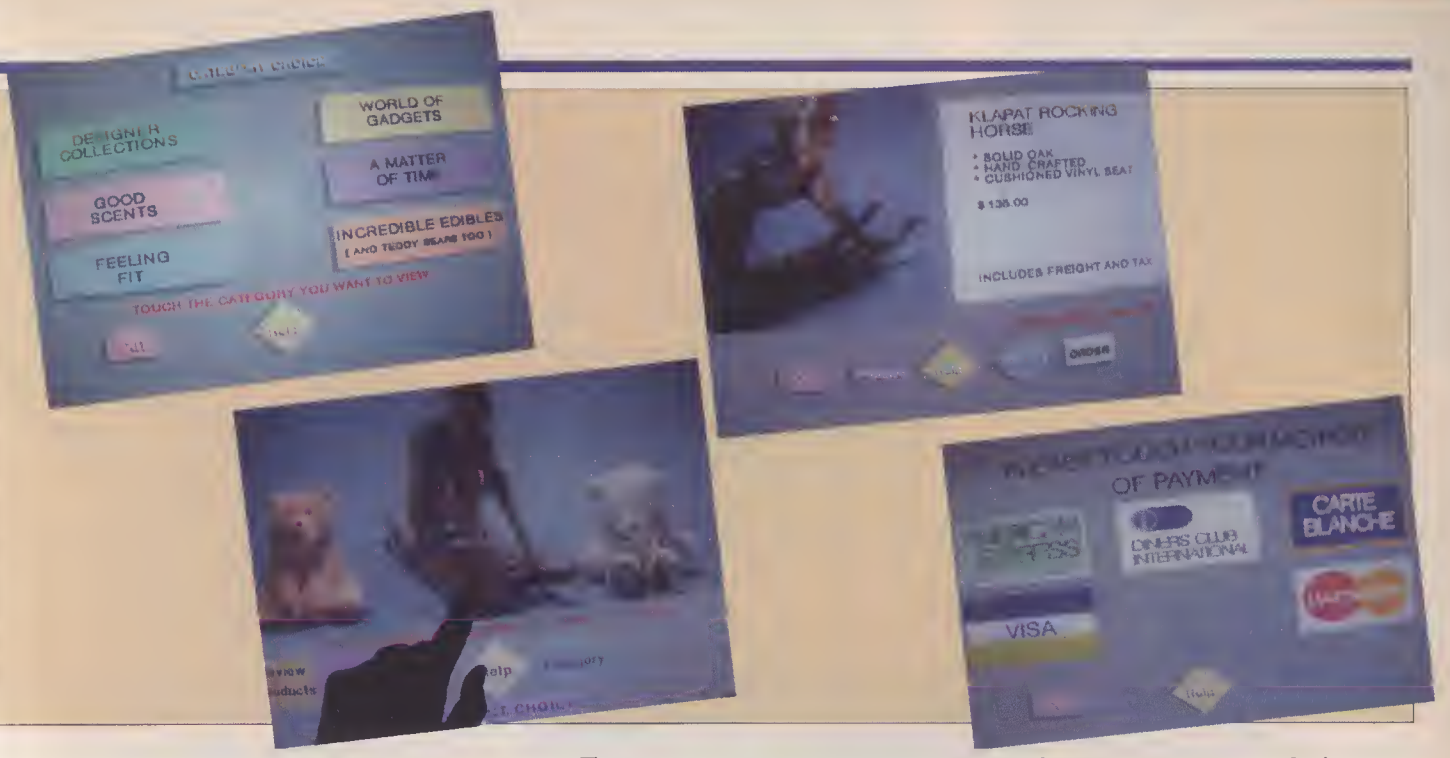
of video images and sound, both of which can be provided by laser videodisc technology. A 12-inch videodisc can store up to 54,000 still frames or 30 minutes of full-motion video segments in either black and white or color. Roughly 10 seconds of sound can be recorded for each still frame.

The most advanced type of interactive videodisc technology (known as Level III) works in conjunction with computer programs that manage the system and provide random access to the information stored on the discs. Thus, as with magnetic computer disks, information doesn't have to be arranged in sequence: the program simply finds the required images or data and pulls them together for display.

Because of their random access capability, videodisc systems operate considerably faster than VCR systems. Meanwhile, the controlling microcomputer permits a variety of presentation formats. For example, a kiosk can automatically scroll through a set of display frames, and then switch to an interactive or transactional mode when a user makes a selection. Some kiosk designs even incorporate an ultrasound device that detects an approaching person and signals the system to switch from scrolling to transactional mode.

Because videodiscs require special recording techniques and can't be erased, they are not suitable for presenting information subject to frequent change. This limitation has been overcome by using the kiosk microcomputer's magnetic disks to store variable information such as prices and promotional features in computer-graphic form. To simultaneously display information from the videodiscs and the magnetic disks, some in-store marketing systems use a two-screen configuration—with one monitor for video and the other for computer graphics. A more sophisticated approach, using a process called genlocking, superimposes computer graphics onto the video image.

Genlocking is achieved by passing the video signal through a time-based corrector circuit. This adds a synchroni-



zation pulse onto which computer graphics can be locked screen by screen in real time. The technique is commonly used on television—for example, when a computer-graphic scoreboard is superimposed over the video at the end of an inning of baseball. With in-store systems, genlocking could be used for applications such as placing current rates over video images of different rooms in a hotel; the controlling computer program combines the permanent video images with the updated computer graphics.

The addition of an autodial/answer modem and communications software to an in-store marketing system allows the operator to load new computer graphics from a central site to update prices or other information. Some systems, including Buick's EPIC, equip their microcomputers with a utility program that allows them to collect data about the users. These data can later be transmitted during off-peak hours to a central computer for use in marketing or customer analysis.

In-store systems use graphics and videos to do everything from selling cars to mapping market aisles.

Various other peripheral devices can also be added to in-store marketing terminals. Printers are used to issue discount coupons, to provide tickets purchased through a transactional service, or to produce hard copies of specific information. Credit card readers have been incorporated by a number of system designers to allow consumers to complete retail transactions.

Electronic in-store marketing systems come in both "closed" and "open" architectures. Closed systems use proprietary components and software, and are sold complete by the vendor. Open systems are based on standard equipment and protocols, and permit users to

Stop&Shop

The supermarket chain's in-store directory features a touch-screen terminal to assist shoppers. The system includes a directory with a map of the aisles to locate specific products, as well as information on coupons and weekly specials. Videotex graphics pages also describe the services of different departments, such as health and beauty aids.

PHOTOGRAPHS BY RICHARD WOOD

mix and match various components as they desire.

Sony (Park Ridge, N.J.), NCR's Personal Computer Division (Dayton, Ohio), and Mitsui (New York) have released closed-architecture video genlocking products. Sony's Visual Information Enhanced Workstation (VIEW), consists of an SMC-2000 microcomputer and an LDP-2000 videodisc player. Like VIEW, NCR's InteracTV system and Mitsui's NAVIC are total system solutions. Both Sony and NCR provide several software development tools that permit designers to build frames of graphics information.

The primary components needed to construct an open-architecture genlocking system are the "superimpose" circuit and the system software. Most superimpose hardware modules are plug-in boards for IBM PC/XT and PC/AT microcomputers and their workalikes. Companies producing genlocking modules include Visage (Natick, Mass.), AT&T (Indianapolis), New Media Graphics (Burlington, Mass.), New Media Technologies (Burnaby, B.C.), Number Nine Computer (Cambridge, Mass.), and NCR.

The V:LINK 1550 and 1580 plug-in boards from Visage are widely used for in-store marketing systems. Most genlocking boards are capable of displaying 16 simultaneous colors from a 4,096-color palette. The TARGA 32 board from AT&T and Number Nine's top-of-the-line board each have a remarkable 16.8-million-color palette. As a result, graphic images produced by either board have a resolution and color gradation that is virtually indistinguishable from continuous-tone video.

System developers can be divided into two broad groups: those using ASCII-based graphics and those using the North American Presentation Level Protocol Syntax (NAPLPS), the North American standard protocol for the production and transmission of videotex images. ASCII systems produce the familiar stair-step block graphics, whereas NAPLPS generates a much smoother image. NAPLPS also incorporates short codes to identify different graphics shapes, a feature that considerably reduces the amount of information that must be transmitted when sending an image. The data compression aspect of NAPLPS can be especially important if the graphics images are transmitted to the in-store system rather than being stored in the system itself.

ASCII developers include Frank Mayer & Associates (Grafton, Wis.), Video Nova (Detroit), VCM Systems (Cedar Rapids, Ia.), ITS Marketing Communications (Cambridge, Mass.), and Digital Techniques (Burlington, Mass.). Companies producing equipment based on the NAPLPS protocol include The Communications Studio (New York), AT&T, Cableshare (London, Ont.), Tayson Information Technologies (Toronto), Formic Videotex Systems (Montreal), and The Genesys Group (Ottawa). IBM has been testing a NAPLPS videodisc genlocking product, but the company won't comment on a release date.

Despite the present enthusiasm for in-store marketing, several analysts and vendors caution against overconfidence. For one thing, businesses are still testing which products can be sold by electronic means. For another, "no one has yet proved that you can consistently make money with these systems," says Peter Heney, marketing director at United Audio-Visual Resources. And Gary Arlen, president of

Ford *Through a process called genlocking, vendors such as Ford can superimpose an eaily updated computer-graphic message on a permanent video (stored on a laser-based videodisc) of their product in action.*

Arlen Communications, a consulting firm in Bethesda, Md., believes that persistent public fear of technology remains a major impediment to the widespread acceptance of electronic in-store kiosks.

Rapidly changing technology represents another problem. "Just knowing that something cheaper and better is always around the corner is a disincentive for many companies to get involved," says Arlen. A number of improvements to videodisc technology, as well as several competing media, already exist. NCR and Sony labs, for example, are hoping to incorporate erasable videodisc technology in their interactive-video products by next year. If videodiscs become a dependable volatile storage medium, mastering costs will plummet and the need for real-time genlocking circuits could decline, since the videodisc itself could be updated.

Today, the mastering costs of videodiscs remain substantial. Bob Tuss, a videotex industry consultant based in Vancouver, B.C., argues that current production costs of roughly $10,000 and four- to eight-week turnaround times for 12-inch videodiscs put many retail applications out of reach. To make the technology affordable, "we will have to move into eight-inch discs and lower-quality reproduction," he says.

Videodiscs themselves, meanwhile, could be gradually supplanted in marketing applications by technologies such as CD ROM or photographic videotex. Like videodiscs, compact discs can hold images, sound, and data, although they are not yet able to store full-motion video. Because the drives for CD ROM media are already in mass production for audio applications, however, they cost considerably less than videodisc units. Last year Digital Equipment (Maynard, Mass.) announced the integration of a 600-megabyte CD ROM optical disc system with its MicroVAX product line. An enhanced MicroVAX/CD-Reader system can support up to 45 remote terminals, which could be used as in-store systems displaying frames stored on the central system.

Going one better than NAPLPS is photographic videotex technology, which displays a complete, continuous-tone image rather than an image made up of discrete colors from an extensive palette. British Telecom has been promoting photographic videotex with its Picture Prestel service, which can send a continuous-tone image occupying 15% of the screen area along with other graphics text in roughly 30 seconds. Photographic videotex requires a large amount of communications bandwidth, but the advent of high-capacity fiber optic networks should accommodate it nicely. British Telecom officials believe this technique will ultimately permit the introduction of videotex teleshopping services into the home.

Many observers, in fact, view in-store systems as a first step toward achieving the ultimate evolution of the marketplace: in-home shopping systems. People who have used electronic marketing elsewhere may be more inclined to use it at home, or so the theory goes. In-store systems "are a vital prerequisite to the lucrative home market," observes consultant Arlen, "because they give retailers and customers a chance to see that electronic retailing will work." □

Paul Hurly, coauthor of The Videotex and Teletex Handbook, *is a freelance writer based in Burlington, Ont., specializing in business and technology.*

For further information see **RESOURCES**, *p. 69.*

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PULLING TOGETHER ON COMPUTER COMMUNICATIONS

A consortium of vendors and users will select standards and certify products

Company managers in charge of computer communications have for years faced a vexing problem: the incompatibility of equipment sold by different vendors. This has come about not only because good international communications standards are in short supply but also because vendors have purposely used proprietary protocols to lock customers into their product lines. In an attempt to improve the situation, a group of companies—both vendors and users—formed a consortium called the Corporation for Open Systems (COS) late last year. The organization, based in Vienna, Va., plans to expedite the formation of international communications standards and to develop the capability to verify that vendors comply.

While COS owes its existence largely to user pressure, another major stimulus was the vendors' realization that the proprietary approach was backfiring. Big customers were delaying many buying decisions because of the unsettled standards issues. Even users with pressing computer communications needs were unwilling to acquire new equipment without assurances that it would solve their networking requirements in the future as well as in the present. The only way to offer such assurances, vendors have realized, is to identify and vigorously support common communications protocols.

by Dwight B. Davis

Set up as a nonprofit R&D consortium, COS had more than 50 members by early summer. In the slow-moving world of standards development, the group has had little time to prove its effectiveness, but many observers are optimistic. COS has enlisted major computer companies such as IBM and Digital Equipment, communications firms such as AT&T and Northern Telecom, and large users such as General Motors and Eastman Kodak. The collective stature of the COS members is impressive enough to virtually guarantee the consortium considerable influence, assuming its members can cooperate.

The inclusion of users is viewed as a key element of the organization; their presence will help COS focus on a protocol's relevance to specific application environments, not just on its technical merits. And unlike standards bodies such as the International Standards Organization (ISO) in Geneva, with which COS will cooperate, the consortium charges a hefty membership fee (see "How COS is organized," p. 32). These fees give the group considerable resources to pursue computer interoperability, and also help ensure the sincerity of the consortium's participants, says Michael Pliner, chairman of member Sytek (Mountain View, Cal.). "People in COS are committed," he says. "They're not just there for a free ride."

One other difference between COS and the standards groups is that the consortium draws on its members' upper-level management, not just their technical personnel. In so doing, COS hopes to gain each company's full support for the issues it tackles and to avoid getting bogged down in lower-level technical disputes. By its charter, in fact, COS will expressly steer clear of developing its own communications standards. Rather, it will survey the available protocols being promulgated by groups such as ISO and the National Bureau of Standards, and will endorse those that it considers the best.

Still, COS has its critics. Some think the organization, which hopes to grow to 100 members by year's end, will be too unwieldly to reach consensus on many issues. Others expect continued foot-dragging on the part of some COS members who may prefer to extend the lifetimes of their proprietary products. And some question the real motivation of the participants. "Most companies have joined COS just to keep an eye on what the competition is doing," claims Steven Payne, president and chief executive officer of PA Computers and Telecommunications, a consulting firm in Princeton, N.J.

ILLUSTRATION BY MICHAEL BLASER

JOHN TROHA/BLACK STAR

COS president Lincoln D. Faurer and IBM representative Ellen Hancock report encouraging cooperation so far.

A response to IBM. Indeed, the founders' motivation was not totally altruistic. Despite many members' true desire for "open" communications systems—those using standard protocols—there is general agreement that COS was initially intended as a counter to IBM's de facto domination of computer communications. "On the order of 70–80% of the major American corporate networks are based on IBM's proprietary Systems Network Architecture (SNA)," says Terence Bentley, director of a service that tracks technology-based companies at the Yankee Group (Boston). Most major computer companies have acquiesced to the SNA standard by building products to link their equipment to IBM's networks, but few relish the prospect of forever following IBM's lead.

Although COS members now downplay this aspect of their organization, Lincoln D. Faurer, the consortium's president, admits that "at the very outset, without question, there was a certain anti-IBM bias." But IBM became a member last winter, and Faurer says he sees no evidence that other COS members are ganging up on the giant in strategy meetings in order to thwart its interests. "This harmonious situation may change in the future," he says, "but at the moment it looks good."

IBM's entry into the consortium took many by surprise. Because the company enjoys the advantages of market leadership in computer communications, it made little sense to some that IBM would choose to promote international standards designed to displace proprietary ones. But Bentley at the Yankee Group believes IBM can continue to promote SNA while moving to co-opt "open systems interconnection" (OSI), a generic, seven-layer model of a communications system—established by ISO and endorsed by COS—in which each layer is responsible for performing different communications functions.

In fact, IBM stands to gain ground by supporting international standards. Gene Manno, group VP of the Small Computer and Office Systems Group at Honeywell Information Systems (Billerica, Mass.), points out that IBM's hold on the computer communications business is not as strong in Europe as in the United States. European users have been much more vocal than their American counterparts in demanding products based on common OSI protocols. As a result, says Manno, "IBM views COS as a way to crack the international market."

For its part, IBM claims that its membership in COS is just the latest indication of its long-time support of open protocol development. "IBM's background is one of active participation in the OSI standards," says Elien Hancock, VP of telecommunications at IBM's Communications Products Division (White Plains, N.Y.). And despite SNA's ubiquity in corporate networks, she notes, "many of our users have installed equipment from other vendors. The clear requirement that we are hearing from our users is that they would like those systems to interconnect."

But at the same time, says Hancock, SNA provides many functions that are not yet delivered by any open protocols. Thus, she adds, "while we support international standards, we will continue to enhance our proprietary standards so that we don't limit our customers' growth."

Some skeptics cite IBM's refusal to commit to replacing SNA with open protocols as evidence that the company is doing little more than talking a good game in support of OSI. This strategy could, at least in the near term, prove successful for IBM, they say, but could leave its customers in limbo. "There's nothing in IBM's statements that allows users to do any planning," says Payne at PA Computers and Telecommunications. Others say that the move toward

How COS is organized

Established as an R&D consortium, the Corporation for Open Systems (COS) consists of a full-time president and administrative staff and volunteer representatives from its member companies. A board of directors consisting of senior executives from the member companies establishes the consortium's overall policy, approves the annual operating budget, and elects the president. COS president Lincoln Faurer, a U.S. Air Force retired lieutenant general, served as director of the National Security Agency from 1981 to 1985.

Probably the key COS group is its strategy forum, charged with developing long-term objectives and choosing standard protocols on which to focus. Forum participants also direct tasks such as the exact specification of endorsed protocols and oversee the development of testing methods for product certification.

There are three membership categories—regular, research, and senior research—each with its own fee structure and participation rights. All COS members pay a base fee of $25,000 per year. Companies with annual computer and communications revenues of more than $25 million must choose to become either research members, at an additional $25,000 per year, or senior research members, at another $100,000 for the first year and $175,000 thereafter. Companies with relevant annual revenues of more than $150 million are required to join as senior research members. Companies joining after October 15 will pay higher research and senior research rates for their first year. COS is considering an affiliate membership class with much lower fees and access to the COS information and testing services, but with no voting rights.

Each senior research member firm may elect one of its officers to the board of directors and one to the strategy forum. Research members must join together in blocks of four, which then elect one person to each group. Regular members do likewise, but in blocks of eight.

The original COS prospectus allowed only North American vendors and users to join the organization. In late June, however, the board voted to admit members from other countries. Such participation is considered essential, since the consortium's goal is to summon global support for international standards.

open systems is so strong that the sincerity of IBM's support may be irrelevant. "Eventually SNA will go away," says Michael Kaminski, manager of GM's Manufacturing Automation Protocol program. "Even an IBM can't fight the standards if everybody else is using them."

COS's Faurer also expects open protocols to gradually displace SNA and other proprietary systems, but he says the consortium isn't ignoring the fact that many vendors and customers have large investments in such "closed" networks. "We're certainly not being unmindful of the standards that exist or of the implications of SNA," he says. Some of the protocols that COS espouses may be derived from de facto standards, therefore, but only if they have first been accepted by the international standards bodies.

The OSI model. So far COS has embraced the generic OSI model. The model specifies no actual protocols, but it establishes the types of functions that standard protocols must perform at different levels in order to span the entire range of communications functions. The lower levels are concerned with relatively straightforward issues, such as the type of physical connection used to attach a computer to a network cable and the routines the computer uses to gain access to the network. Going up the seven-level stack, one encounters layers designed to perform such tasks as routing information within the network, ensuring error-free transmissions, and converting data from one format to another. At the very top of the stack lies an application layer, which provides services relevant to the actual tasks being performed by the network users. A protocol designed to facilitate the sending of messages, for example, would directly support the user application of electronic mail.

Because different users have different needs—say, for a certain type of network medium or of application support—a number of different protocols have evolved at each level of the OSI model. The most familiar of these are the different local-area networking standards, such as Ethernet and the IBM token ring, which embody protocols at the lowest two levels.

Even with its impressive membership list, COS will succeed only if it endorses standards that are popular among users; thus the user companies within COS could play an important role by educating the vendors about their actual communications needs, thereby helping the group avoid some of the more esoteric protocols. In fact, the consortium's initial focus will be on upper-level protocols that relate directly to the users' applications.

Well-defined user needs will be especially valuable in helping the consortium pare down the number of options allowed within some published standards. These options sometimes prevent the linking of products from different companies, even though they incorporate the same nominal protocol. Some options address different technical requirements, such as variations in the physical interface specifications to let customers run their networks over different media. However, some options reflect vendors' desires to insert parts of their proprietary protocols into the standard, regardless of their technical merit. "The tendency on the part of the standards groups when compromising in such cases is usually on the side of inclusion," notes Theodore H. Myer, director of Standards and Technical Planning at GTE Telenet Communications (Reston, Va.).

The MAP specification. Before the formation of COS, user companies became involved in the standards process through groups such as the Network Users Association, which, like COS, promotes standards activity. The most notable example of user influence, however, is that of General Motors, which created the Manufacturing Automation Protocol (MAP) specification to meet its networking requirements on the factory floor. MAP follows the OSI model, incorporating various internationally established protocols at several of the seven functional levels. GM has used its economic clout as a major buyer of communications equipment to pressure suppliers into supporting MAP on their products.

A related specification, developed by Boeing and called the Technical Office Protocol (TOP), mirrors many of the MAP protocols at the intermediate levels of the OSI stack. It differs in its physical connection and access methods, however, and in some of its high-level protocols, since it is concerned with tasks such as electronic mail rather than file transfers between factory-floor computers. MAP and TOP are similar enough that a 1300-member user group has formed to promote and implement the two specifications, but they are in fact different "protocol stacks" that address different applications.

The existence of multiple "standard" protocols at each level of the OSI model confuses some users who have heard much talk about an era of "universal connectivity," in which all types of computers and peripherals could communicate with each other unassisted. But as the MAP and TOP specifications illustrate, different applications will re-

quire different protocols at certain layers. And networks based on different protocols can't communicate with one another without the assistance of devices that perform protocol conversions. Given the large number of applications, says Honeywell's Manno, "universal connectivity is in the same realm as the tooth fairy."

But if a limited list of standard protocols can eventually replace the many proprietary protocols now operating in the market, the building of communications "gateways" to connect the different networks will be greatly simplified. And if the networks have some protocols in common, as would a MAP and a TOP network, the interconnection between them will be simpler still.

Pressure to succeed. Initially, the COS consortium is focusing on individual upper-level protocols, not on complete protocol stacks such as MAP and TOP. Its top priority is the specification and testing of two level-seven protocols supported by ISO. The first, X.400, is a message-handling protocol for store-and-forward electronic mail applications; the second, file transfer and access methods (FTAM), permits the real-time exchange of computer-based data.

To help establish the consortium's effectiveness, Faurer is pushing to create an in-house testing and certification center to verify that members' products conform to these standards. Eventually, volunteers from the member companies will develop the COS testing procedures. But in an attempt to get a test capability up and running by sometime next year, COS has issued a request for proposals to outside companies for the development of X.400 and FTAM tests. If successful, the testing procedures may establish the COS seal of approval as a valuable marketing tool.

Faurer considers the consortium's early goals to be "fairly modest compared to what will follow," pointing out that COS is still in a start-up mode. But that modesty should remain for awhile, believe some members. "One of my fears is that COS now has so much money"—approximately $6.5 million through membership fees—"that it may go off in too many directions and spread itself too thin," says Judith Estrin, executive vice-president of Bridge Communications (Mountain View, Cal.). In addition, Sytek's Pliner, who is also concerned about COS "trying to do too much too soon," believes the rapid growth of COS membership may prove troublesome. "When you get 20 or 30 new members very quickly," he says, "a lot of assimilation must first take place before coming up to speed."

Of all COS's goals, Estrin believes that the ones the consortium should concentrate on are the establishment of testing procedures and the dissemination of information. She questions the organization's ability to expedite the development of new standards within the established standards bodies. "That just happens at a certain pace, and there's little COS can do to speed it up," she says. But Faurer notes that many COS members are also members of various standards bodies; if they can present a united front during standards deliberations, that will certainly accelerate the process. (COS itself won't at-

Seven-layer OSI model

User application program

Layer 7: application
Provides communications services in formats comprehensible to the application programs

Layer 6: presentation
Transforms data to and from various standard formats

Layer 5: session
Synchronizes and manages the exchange of data among senders and recipients

Layer 4: transport
Provides transparent and error-free transfer of data between nonadjacent network nodes

Layer 3: network
Performs message routing for data transfer between nonadjacent nodes

Layer 2: data link
Manages network access and performs error detection for messages moved between adjacent nodes

Layer 1: physical
Specifies the electrical connections to the network and encodes and transfers messages between adjacent nodes

Each layer of the "open systems interconnection" model addresses specific networking requirements. Standards bodies are creating protocols that perform the various functions.

Although initially skeptical, Sytek's Michael Pliner now believes the consortium will succeed.

STEVEN MANGOLD

BUSINESS OUTLOOK

Intercompany network vendors look forward to standards

Widespread acceptance of data communications standards will have a profound effect on the entire telecommunications industry. But the segment experiencing its earliest effects will likely be the fledgling electronic data interchange (EDI) market. An EDI is a network that allows computers within one company to exchange information with computers at its suppliers and customers, whether or not such computers are all from the same vendor.

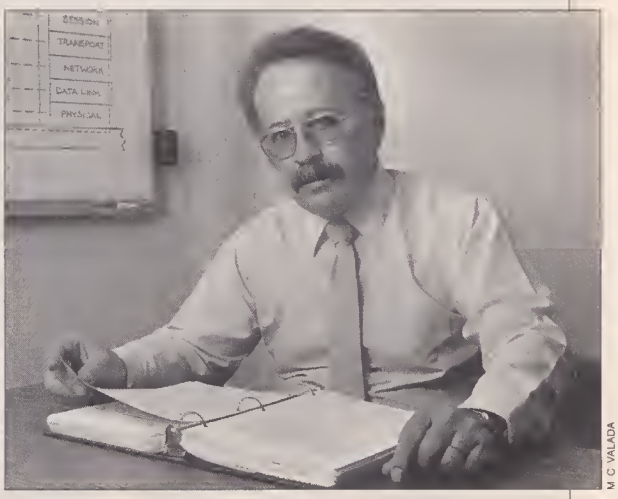
The growing demand for intercompany networks is due largely to the successes of firms like General Motors in Detroit and American Hospital Supply in Evanston, Ill., in boosting profits by establishing EDI systems. GM is swapping data with its suppliers about purchase orders, inventory levels, and projected product demand to shorten supply lead times and reduce parts inventories, while American Hospital claims to have tripled its revenues by providing its customer hospitals with terminals for electronic ordering.

GM and American Hospital were able to set up their own EDI networks. Most companies, however, are looking to third-party vendors to provide the communications and software services necessary to tap into the computers of firms with which they do business. Such vendors are vying for a $20 million U.S. market, which should leap to $500 million by the early 1990s, according to David Foster, VP of GE Information Services (GEISCO) in Rockville, Md.; an additional $300 million could come from U.S. firms seeking to hook up to foreign business partners.

"A high proportion of Fortune 500 companies are going to make decisions about electronic data interchange over the next few years. The emergence of data standards would add momentum to this market."

David Foster, VP
GE Information Services

There are presently a dozen companies in the EDI market. The top four firms—GEISCO, McDonnell Douglas (St. Louis), IBM (Armonk, N.Y.), and Control Data (Minneapolis)—are each taking in $2–4 million in revenues at present for EDI services offered over their own networks, according to Link Resources (New York). Second-tier EDI firms generally lease lines from the larger vendors for resale to customers. The leading EDI firms tend to focus on specific sectors. Thus GEISCO has been aggressive in the office-product, paper, healthcare, and automotive aftermarket industries, while McDonnell Douglas receives 75% of its EDI revenues from the grocery industry.



M. C. VALADA

"So far, intercompany networks have primarily linked vendors and suppliers in the automotive industry. Now utilities, banks, and brokerages, among others, are interested in such networks for their own sectors."

John Neumann, VP
Omnicom

"For the most part, the evolution of data communications standards should have a positive impact on the EDI market over the next few years," says A. G. W. Biddle, president of the Computer and Communications Industry Association (Washington, D.C.). Standards will significantly ease the task of tying diverse computers together, which then should stimulate more firms to take advantage of the efficiencies made possible by intercompany networks, according to John Neumann, VP of Omnicom (Vienna, Va.), a communications consulting firm. For this reason, EDI firms generally welcome the efforts of standards institutions.

On the other hand, increased standardization could open the way for more competition. At present, vendors must incorporate into their services such features as protocol conversion, which enables computers of different brands to communicate with each other, and data format translation, which ensures, for instance, that a purchase order date sent by one company's computer is not interpreted as a price by a computer at another firm. These features would be less complex if standards became widely accepted, making it less costly to provide EDI services. This, in turn, would make it easier for more communications-oriented businesses to enter the market. The current EDI leaders, however, anticipate that they can at least retain market share on the basis of their expertise in establishing and maintaining EDI operations, in addition to the network capabilities and communications software they offer.

Standards also open the way for the proliferation of more modestly sized EDI networks, initiated by firms that deal with smaller groups of suppliers with whom continual contact may not be necessary. At present, such end users obtain help from a few software companies, including Sterling Software Marketing (Rancho Cordova, Cal.) and Data Design Associates (Sunnyvale, Cal.), rather than from the full-service EDI vendors. These companies provide clients with data-format and other specialized EDI software, some of which is tailored to the personal computers common in "mom and pop" supply operations. "The acceptance of standards would explode our sales," says David Swanson, product manager at Sterling, "by convincing a larger pool of companies that EDI is not just for industrial giants."***—David H. Freedman***

tempt to directly influence the standards bodies, however, although it has established subcommittees to facilitate the exchange of information between them.

Member benefits. The potential for COS members to act as a voting bloc at standards meetings is one of the main attractions to joining the organization. For smaller members who cannot hope to belong to all the various standards bodies themselves, COS provides a forum at which they can make their preferences known and perhaps influence the consortium's stance on particular issues. The role of COS in maintaining a flow of information from the many standards bodies to its members is also of crucial concern to members unable to track all the activity themselves.

Still, many companies want some hard payback to justify the high cost of COS membership. For most, the key benefit will be the early COS testing and certification of their products. But although there is a general sentiment among COS members that they should have a two- to three-year lead time over nonmembers, the establishment of a policy in this area poses some dilemmas for the organization. The most obvious is that COS professes dedication to open protocols for *all* vendors and users, not just its members. It must therefore "spread the gospel" and attempt to get broad support for the standards it endorses, notes Faurer. Nonmembers might not rush to implement the protocols COS endorses if they are faced with a long delay in getting their compliance certified. And if the COS members are seen as gaining too much of a competitive advantage, the consortium's activities could come under antitrust fire.

Once COS has established a policy toward nonmembers, it will license its verification technology to commercial testing firms, which could offer their services to all comers.

Beyond the presumed payoffs of COS leverage in the standards process and certification lead times, the consortium's members stand to gain one more important benefit: good PR. "If COS is successful, it will confer a high-quality image on its members," says GTE Telenet's Myer. Bridge's Estrin agrees. "By joining COS," she says, "we're demonstrating our commitment to standards, which is an important marketing issue for us."

COS evolution. Although its initial work will focus on communications protocols, GM's Kaminski believes the consortium may eventually tackle broader standards issues once it achieves some progress in this arena. Even with common protocols, the task of linking different computers is hampered by the fact that they run different types of "systems" software such as operating systems. "The potential certainly exists to get COS to address a standard operating system as well as to explore international graphics standards and programming languages," says Kaminski.

While COS president Faurer maintains that the consortium's agenda is now more than filled with its communications activities, he agrees that COS will probably branch out in the future. In particular, he says that "COS will help address such issues as personal privacy and national security, which are raised by the increased ease of computer communications."

In the long run, Faurer believes, COS will help the entire computer and communications industry by establishing support for all types of standards. "Then resources once used to achieve compatibility can be spent on innovation," he says. The Yankee Group's Bentley holds a similar view. "One of the reasons vendors have decided to back COS is that they are getting pretty damn tired of investing R&D dollars in every possible direction," he says. "Protecting their proprietary installed bases has been costing them more business than it's been gaining them." □

GM's Michael Kaminski says the company will use COS to push its Manufacturing Automation Protocol.

COS Members*

ADC Telecommunications (R)
Aetna Life & Casualty (M)
Amdahl (S)
Apollo Computer (S)
Apple Computer (S)
AT&T (S)
Bechtel Power (M)
Bell Communications Research (S)
Boeing Computer Services (S)
Bridge Communications (R)
Burroughs (S)
Citicorp (M)
3Com (R)
Concurrent Computer (S)
Control Data (S)
Convergent Technologies (S)
Dart & Kraft (M)
Data General (S)
Digital Equipment (S)
Dow Chemical (M)
Du Pont (M)
Eastman Kodak (S)
The Equitable (M)
Excelan (M)
General Electric (S)
General Motors (S)
Gould (S)
GTE Telenet Communications (S)
GTE Service/Telephone Operations (M)
Harris (S)
Hewlett-Packard (S)
Honeywell (S)
Hughes Aircraft (M)
IBM (S)
Intel (S)
ITT (S)
Motorola (S)
NCR (S)
National Semiconductor (S)
Network Systems (S)
Northern Telecom (S)
Pacific Bell (S)
Prime (S)
Proctor & Gamble (M)
Rockwell (S)
Sperry (S)
Sun Microsystems (R)
Sytek (R)
Tandem Computers (S)
Telex Computer Products (S)
Texas Instruments (S)
Touch Communications (M)
Visa International (M)
Wang Laboratories (S)
Xerox (S)

Key

(S) Senior research member
(R) Research member
(M) Regular member

* As of 7/15/86.

Dwight Davis is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 69.*

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This micro-laboratory makes it possible to segregate, manipulate and "tune-in" on individual electrons. (Listening to electrons one at a time is like listening to the clapping of one person in the crowd at the Olympics.) By studying electron flow at this minuscule order of magnitude, AT&T has produced some fundamental revelations about the sources of circuit noise.

The Rocks In The Rapids

As electrons move through the narrow circuit, they behave both like waves and like particles. The particles can be troublemakers. Some produce obstacles in the form of charged atoms—atomic "rocks" that create disruptions in the flow of current, much the way rocks create the "rapids" in a stream.

Noise—in the form of individual "clicks"—comes from sudden changes in current flow as single electrons create and destroy atomic "rocks." Now, using our narrow-channel transistor to study these disruptions in current flow, we are able to identify the individual clicks that comprise data-obscuring noise in ultra-small circuits.

Listening to electrons one at a time.

Quiet! Electrons At Work

Identifying the source of electron noise is a big step toward removing it. But, AT&T is already working on the next step—experimentally altering the nature of atomic obstacles to reduce their effects.

As the number of components on silicon integrated circuit chips continues to increase—by a factor of as much as 100 each decade—a knowledge of noise becomes critical. Today, AT&T packs 2 million components into its megabit memory chip; by the late 1990s, 100-million-component chips should be possible.

A consistent world leader in microelectronics, AT&T will continue to probe the physics of the very small, building on the advanced research made possible by a laboratory on a chip.

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TAKING THE GUESSWORK OUT OF DRUG DESIGN

Drugs that fit hand in glove with specific cells have fewer side effects and can be developed faster

by Roger S. Johnson

Until recently, most new pharmaceuticals arose from folk cures, costly and time-consuming tests on animals and humans, and simple luck. It was usually only years later that researchers learned how the drugs actually worked.

But new knowledge about "receptors"—complex proteins on the surfaces of living cells, where reactions with drug molecules take place—promises to make new-drug design speedier and more predictable. By matching the geometric shapes of potentially therapeutic molecules to their corresponding receptors, pharmacologists may soon be able to create more effective drugs while eliminating adverse side effects; in some cases, it may also be possible to avoid months of tedious, often inconclusive animal testing. In addition, receptor technology (RT) could prove to be a valuable screening tool, helping researchers assess the medical value of hundreds or thousands of existing proprietary compounds.

Although still a young technology, RT has already led to several promising new drug candidates. Some of them will be targeted to the nervous system, perhaps resulting in more effective, nonaddicting painkillers and tranquilizers. Others may provide improved relief for asthmatics, while still others are being developed to combat coronary disease and hypertension. What's more, investigators have recently discovered receptors at which no known drugs interact—mystery doors waiting to be unlocked.

"Receptor technology *is* the pharmaceutical industry," says Stanley Crooke, president of R&D for SmithKline & French Laboratories (SKF) in Upper Merion, Pa. "We are seeing unbelievable advances with numerous new targets for drug action." The company has recently used RT to design its new diuretic (an agent that promotes urine output) called a vasopressin-receptor blocker. The diuretic is now undergoing patient safety tests and will be marketed as an antihypertension drug. "It is the first diuretic that targets the excretion of only water," says Crooke. "There is no [potentially hazardous] salt loss." Meanwhile, at least one company—Nova Pharmaceutical (Baltimore)—has been started just to exploit receptor concepts in its search for new neurological products.

Despite such enthusiasm, it's not yet possible to predict the technology's economic payoff for the U.S. pharmaceutical industry, which in 1985 enjoyed revenues of $30 billion. One important reason is that while several therapeutics developed with receptor techniques are now in clinical trials, they are only in early stages of evaluation by the Food and Drug Administration (FDA). Another caveat is that not all drugs function via a receptor mechanism. Most important, the technology is still considered highly experimental in some research circles; until it enjoys much wider acceptance, it will supplement rather than replace conventional methods of drug design and testing.

Locks and keys. It is convenient to think of receptors as biological locks, and the synthetic or natural chemicals that react with them as keys. As such, receptors play crucial roles in the body by regulating its interactions with pharmaceuticals, hormones, and other molecules.

The most important difference between one receptor and the handful of others on the same cell is the geometric shape of its binding site (the region that actually combines with other molecules); that in turn is determined by the unique amino acid sequence that forms the protein. When a molecule engages this binding site, there are two possible results. The molecule may act as an "agonist," opening the biological lock and producing a series of reactions by other cells—the twitching of a muscle cell, for example. Alternatively, it may act as an "antagonist," jamming the lock by sealing off the receptor to other molecules. The jamming may inhibit a normal chemical response, such as the transmission of a pain signal.

Molecules can often be designed to trigger either response. Once the receptor's binding-site architecture is known, a selection of molecules—all with the same binding geometry but with different molecular features that dictate shape, electrical charge, and chemical reactivity—can be experimentally fitted into the receptor. Researchers can then study such characteristics as therapeutic effect, duration of activity, and side effects.

Receptor binding sites are usually analyzed indirectly by learning which compounds bind to them. Working with isolated cell or tissue cultures, for example, the "radioreceptor assay" measures the binding of a drug molecule to receptors that have already bound to an isotope-labeled molecule, such as a hormone. The extent to which the experimental molecule displaces the isotope is a measure of its affinity for the receptor.

Another *in vitro* assay, called autoradiography, actually maps a drug's activity sites within the body and helps predict the drug's effects. Isotope-labeled drugs are injected, one at a time, into the tissue. (The tissues are usually taken from animals, whose cell receptors are often very similar or identical to those in humans.) The tissue is then photographed with a special camera; the resulting computer-generated image locates and quantifies the drug-receptor binding sites.

A variation on this method, based on the brain-imaging technique called positron emission tomography, has recently provided real-time images of receptor sites and their chemical activity. The patient is injected with a small amount of short-lived isotope-labeled drug; as

Receptor know-how is providing "unbelievable advances" in pharmaceutical design, says Stanley Crooke, R&D president at SmithKline & French. The company is using the technology to design several new drugs for controlling high blood pressure. Also on the agenda is a treatment for the painful heart condition known as angina.

the radioactivity decays in the brain, positrons (positively charged particles) are emitted and recorded by detectors surrounding the patient's head. The images provide a safe and virtually noninvasive method of studying drug interactions, effectiveness, safety, and sites of action in humans.

Understanding the brain. Designing new drugs that act on the brain is one of RT's most promising applications—and one of the most complex. It is often difficult to devise reliable drug assays for testing the nervous system, and the assays that do exist don't always relate to mental function and disease. Unlike other body tissues, whose reactions to drugs are often clear and immediate, "the brain doesn't twitch," explains one researcher. However, recent knowledge about specific brain receptors, especially those regulating pain, anxiety, and excitability, provides a new approach to treating neurological disorders.

Opiates, for example, react with several types of closely related receptors; depending on the receptor, the binding results in pain relief, euphoria, sedation, or increased or decreased appetite. The efficiency of many current drugs is often compromised, however, because they sometimes bind with nontarget receptors.

No one has yet developed an ideal opiate pain reliever (one that is completely effective, nonaddicting, and without side effects), but several companies claim to have candidates. Nova has two oral analgesics, for example, and is developing longer-acting second-generation compounds that it claims could become as widely used as codeine. The reason these drugs provide longer pain relief, according to Nova's animal tests, is that they are as potent as morphine but stay bound to the receptor three times as long.

The new opiates are also reported to have fewer adverse effects, according to Solomon Snyder, a neuroscientist at Johns Hopkins University (Baltimore) and a member of Nova's advisory board. And while all opiates are at least slightly addictive, he says, Nova's appear to be less so than others because they produce less of an emotional "high"; they also cause less respiratory problems and constipation. The company's animal trials are nearly completed, and Nova hopes to win FDA approval this year for a "compassionate" IND (investigative new drug). The designation will allow physicians to use the opiate in patients suffering intractable pain.

Not surprisingly, Nova has plenty of competition. RT researchers at Upjohn (Kalamazoo, Mich.) have developed a potent analgesic that is highly selective for the opiate "kappa" receptor, according to senior scientist Robert Lahti. As with the Nova compound, animal studies suggest that it is as potent as morphine but much less addictive because it binds only weakly to the opiate "mu" receptor that is associated with euphoria. The Upjohn drug is now being tested for safety in humans.

Upjohn scientists have also discovered a unique class of antipsychotics

LOUIS BENCZE

New opiate painkillers stay bound to their brain receptors longer, says Johns Hopkins neuroscientist Solomon Snyder, and thus provide more lasting relief. The drugs are also less addictive than other opiates because they bind with fewer nontarget receptors, producing less of a "high."

that bind selectively at "type-two" dopamine receptors. (The chemical dopamine is an important component of the nervous and cardiovascular systems.) Because the new drugs bind poorly to other receptor types, they cause fewer side effects, such as the motor disorder called tardive dyskinesia.

Other companies are using receptor technology to develop antianxiety drugs. One example is quazepam (one of the family of drugs called benzodiazepines) from Schering-Plough (Bloomfield, N.J.). The drug has a "markedly improved 'sleep architecture' versus Dalmane or Valium," says Irving Tabachnick, vice-president of drug safety and metabolism. By binding exclusively to the "type-one" benzodiazepine receptors, he says, "it has purely sedative effects and fewer deleterious effects, such as amnesia."

Meanwhile, Ciba-Geigy (Summit, N.J.) is developing a new class of drugs that react with benzodiazepine receptors to enhance awareness and cognition. These compounds "would not have been discovered without the benzodiazepine receptor assay," says Michael Williams, a receptor researcher at the company.

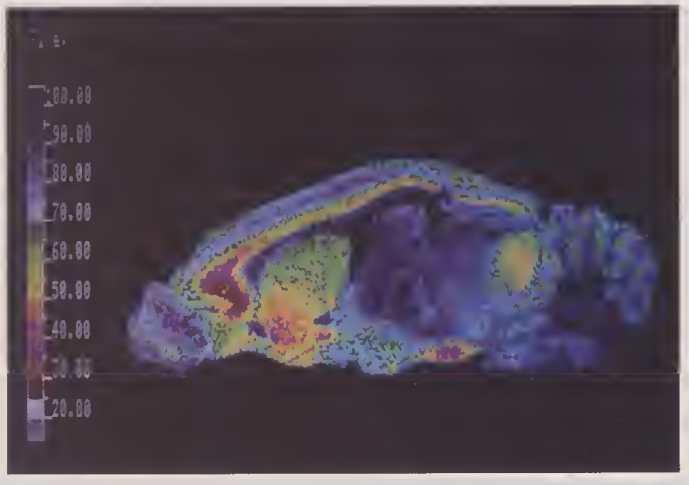
Help for asthmatics. RT is also being employed in several other areas of healthcare known to involve receptors. For example, researchers are convinced that new therapies for some sufferers of allergic asthma (for whom no truly effective treatment now exists) can be designed by blocking an appropriate receptor. At SKF, the theory has led to a new class of drugs called leukotriene antagonists. Leukotrienes are hormones that contract smooth muscle cells, especially in the airways; their production is stimulated in allergic-asthma patients by foreign particles called allergens.

No current asthma medication acts on leukotriene receptors; drugs that do relieve the symptoms are thought to do so indirectly (and usually weakly), often by relaxing the airway muscles. SKF's strategy is to use a receptor antagonist to block leukotriene binding at its receptor. The company claims to have devised a reliable leukotriene assay for measuring the drug's binding characteristics; until human trials are completed later this year, however, SKF declines to release any significant information on the product.

Nova is also on the trail of an effective new asthma drug, and claims to have tested receptor antagonists that are 70,000 times as potent as the widely prescribed asthma drug theophylline—a powerful demonstration of RT's ability to design drugs that bind more specifically to a given receptor. "It's probably the most marked enhancement of potency ever attained," says Snyder. Because of the higher potency, patient doses could be greatly reduced (along with the chances of adverse side effects). The Nova compounds are now being tested in animals.

Several RT-based drugs are also being explored for treating cardiovascular disorders. By and large, the drugs hang on the concept of subtypes—structurally related receptors that exist on cells other than the primary target cells and that sometimes lead to undesirable side effects by binding the drug molecule. For example, the heart is rich in "beta-one adrenergic" receptors, while the lungs are rich in the slightly different "beta-two" receptors. The most efficient of the heart drugs called beta blockers bind only to the first type of receptor, while less selective versions bind to both—sometimes resulting in serious pulmonary problems. The side effects might be eliminated by fine-tuning the drug to select one subtype over the other.

A cardiovascular drug developed by SKF may regulate some kinds of hypertension by reacting with what appears to be an adrenergic receptor subtype; the treatment is now in early human trials. Another antihypertension drug



UPJOHN CO

This section of animal brain tissue was treated with a radioisotope-labeled drug that binds preferentially to the biologically reactive cell structures called opiate "kappa" receptors. The red and yellow tints indicate areas where the concentration of the drugs—and hence of the receptors—is highest.

in clinical trials, called fenolopam, relaxes blood vessels in the kidneys and increases urine output by reacting with certain dopamine receptors. Yet another potential cardiovascular treatment designed by SKF is an antagonist that binds a different class of dopamine receptors, thus reducing the secretion of certain heart-stimulating hormones and decreasing blood pressure and cardiac oxygen demand. The drug may prove to be a novel and effective treatment for angina (a painful heart condition), according to a company source.

Some heart disorders might also be treated with new prostaglandin-like compounds now being designed with RT. Prostaglandins are natural body chemicals that act on smooth muscle cells—they cause uterine contractions, for example, and are sometimes used to induce labor—and that seem to regulate blood clotting.

Researchers at Squibb (Princeton, N.J.) are testing several prostaglandin antagonists, hoping to block the receptor and thereby reduce smooth-muscle contraction in blood vessels. The antagonist might also be helpful in controlling the clumping together of platelets—a process vital to clotting—and could thus be an important aid for coronary patients who have already been treated with surgery or drugs. One such family of drugs (called thromboxane A2 receptor antagonists) is now undergoing clinical trials, according to George Mackaness, president of the Squibb Institute for Medical Research.

RT has also been used in new-drug safety studies, specifically for the cardiovascular drug called betaxolol. The drug was originally developed in Europe for treating heart disease because of its high beta-one receptor selectivity; however, other researchers learned that the drug had an unusual side effect: it relieved some glaucoma symptoms when used as eye drops.

Because of betaxolol's known effects on the heart, its U.S. supplier—ophthalmic drug producer Alcon (Fort Worth, Tex.)—had to convince the FDA that betaxolol eye drops had no undesirable effects in cardiac patients. Working with patients receiving the eye drops, Jon Polansky, a researcher at the University of California at San Francisco, withdrew small blood samples and tested the blood against receptors in heart and lung tissue. The very low receptor-binding rate indicated that blood levels of betaxolol were so low that the drug posed minimal risk to cardiac patients. Alcon is also using the RT data as a convincing sales tool for marketing betaxolol to physicians, many of whom were skeptical about the drug's safety for glaucoma patients who also suffered from cardiac problems. During its first two months of sale, in fact, betaxolol captured 23% of the market for ophthalmic beta blockers (a $200-million-a-year market that was previously served exclusively by Merck's timolol).

New life for old chemicals. Besides its role in the design of new drugs, RT is proving to be a valuable tool in other areas—screening existing drugs for therapeutic effects, for example, and assessing a compound's cross-reactivity (the degree to which a drug might produce adverse side effects by binding to more than one receptor).

Many drug companies are now screening existing chemicals for activity at newly found receptors—a process similar to searching through a pile of keys for one that opens a lock. One benefit could be "new therapeutic applications for the thousands of untested chemicals on the shelves of most major drug companies," says neuroscientist Julius Axelrod at the National Institutes of Health (NIH) in Bethesda, Md., and a member of Nova's scientific advisory board. "We use RT as the primary screen whenever possible," says Ciba-Geigy's Williams. "The philosophy is to believe RT until proven otherwise."

RT offers several advantages over animal trials: not only is it faster and less expensive, but it requires a fraction of the amount of drug needed for animal tests, and spares animals in the early drug development process. A single rat brain provides enough receptors for several hundred binding assays, whereas evaluating drug dosages in live rats may require 20–40 animals. At Nova, for example, every new drug's receptor characteristics are known before it is used in animals.

Receptor technology may provide new treatments for heart disease, asthma, and severe pain.

RT's value over animal tests—as well as its potential for saving corporate funds—has been dramatically demonstrated in several instances. For example, two companies recently used conventional animal tests to develop antiasthma compounds. Although the drugs were effective in guinea pigs, they were almost completely ineffective in humans. Researchers later discovered that neither compound bound to leukotriene receptors in either species; that is, the antiasthmatic effect in animals was apparently unrelated to receptor binding. RT assays earlier in the process would almost certainly have provided the same information—but without the costly animal trials.

Still, RT technology has its limits. In their search for new pain relievers, for example, Du Pont researchers in Wilmington, Del., have checked thousands of proprietary compounds for opiate-receptor binding, according to Leonard Cook, chief of pharmacology research for central nervous system drugs. But Cook notes that many of the candidates are also examined in animals, since some drugs, such as aspirin, do not operate via a receptor mechanism.

Sounds of dissent. As in the case of any emerging technology, the long-term value of RT is not universally recognized, even for developing drugs that function via receptors. One reason is that isolated receptors in a laboratory are not organized the same way as in the body, and so may react with a drug differently. "Lots of compounds that block receptors *in vitro* are not active *in vivo*," explains Squibb's Miguel Ondetti, vice-president of cardiopulmonary diseases.

Nor is it likely that RT will ever become the sole route to new-drug design. Because receptor activity may be influenced by its physical and chemical surroundings (among other factors), key R&D decisions will always rest heavily on conventional animal and human trials. "We would not take a drug developed exclusively by *in vitro* receptor binding through a final decision point," says Andre Salama, a senior investigator at Stuart Pharmaceuticals (Wilmington, Del.). Because receptor assays often reveal so much about a drug's mode of action, however, RT will become an increasingly important supplementary tool by minimizing the costly trial and error that typifies early-stage drug research.

The FDA presents another fuzzy factor in RT's future. Although several receptor-designed drugs are now in clinical trials, the agency is only now beginning its evaluation process. "It isn't always enough to demonstrate that a molecule reacts with a receptor," says Robert Temple, the FDA's chief of new drug applications. "You must also know what all the receptors do, and what happens when the molecule binds with them." The results of such bindings are clear in some cases, such as with beta blockers, because both the receptor and its function are well understood; the identity and function of the various brain receptors—and the results of their binding with a chemi-

BUSINESS OUTLOOK

Receptor technology could push pharmaceutical sales

Receptor technology (RT), which targets drugs to particular sites on a cell that trigger or block specific biological responses, is expected to become an efficient and economical alternative to the trial-and-error methods typical of traditional drug design, especially during the early stages. Proponents also claim that RT-based drugs cause few or no adverse side effects and that RT can play a significant role in drug testing.

Some of the largest companies in the pharmaceutical industry are exploring receptor technology, including Upjohn (Kalamazoo, Mich.), Schering-Plough (Bloomfield, N.J.), Ciba-Geigy (Summit, N.J.), SmithKline & French Laboratories (Upper Merion, Pa.), Squibb (Princeton, N.J.), Du Pont, and Stuart Pharmaceuticals (both in Wilmington, Del.). At least one firm, Nova Pharmaceutical (Baltimore), was founded expressly to develop and apply RT.

The only RT product that has earned revenues so far is a drug-screening process operated by Nova to test the impact on cell-receptor sites of substances provided by Eastman Kodak and other clients. Otherwise, the first generation of RT-based drugs is still in the preliminary stages of research and evaluation by companies and the Food and Drug Administration (FDA). However, the industry is looking forward to producing drugs that will be part of the most lucrative pharmaceutical markets.

The product classes of chief interest to RT researchers include cardiovascular drugs, which had U.S. sales to pharmacists of $3 billion last year, according to Pharmaceutical Data Services (Scottsdale, Ariz.), asthma drugs ($437 million), antianxiety drugs ($716 million), antipsychotics ($248 million), prescription pain relievers ($261 million), and antihypertensives ($731 million). While it is premature to project market figures for specific drugs derived from RT research, one indication of the potential is the $1 billion market for the cardiovascular therapies called beta blockers. These drugs were developed by classical methods rather than through RT research, but were found to act specifically on heart-muscle cell receptors called beta-one adrenergic receptors.

RT-based drugs, when they appear, are likely to affect the market share held by traditional products and to open up new arenas for drug applications. For example, the first drug to emerge from RT research will probably be a spray-on formulation of Nova's antagonist (receptor-blocking agent) for bradykinin, a tissue hormone that is a potent pain-producing agent. As a localized pain reliever, the antagonist would compete with such products as cortisone creams, sunburn remedies, and poison-ivy salves. Nova, now readying the antagonist for clinical trials, expects the compound to work without penetrating the skin, a property that would lower the FDA's requirement for toxicology data and speed the product's entry into the marketplace. Nova is also researching a version of this product for use throughout the body.

Ciba-Geigy and other firms are in the early stages of RT research on cognition and awareness enhancers that could possibly be used to treat forms of senile dementia like Alzheimer's disease. Over 2.5 million Americans suffer from Alzheimer's, a number expected to increase as the U.S. population ages. "There are at present no FDA-approved drugs for the treatment of Alzheimer's disease, and there's nothing on the market that makes someone remember better or think more clearly," says David Bartash, a VP at Dean Witter (New York). "A drug that could do that would be a genuine breakthrough."

It will take time to refine RT techniques into generally accepted methods for developing important new substances. "RT will greatly accelerate the pace at which drugs can be brought to the point where clinical trials can begin," says Lloyd H. Schloen, VP of corporate development at Nova. "Major drugs developed through RT should reach this point within the next three years." One problem that might then slow commercial applications, however, is that drugs could be developed before the means are available to deliver them to receptor sites, according to Anthony A. Sinkula, director of drug-delivery systems research at Upjohn. "The total timeframe here for commercialization of RT-based products is eight to fifteen years," he says. ***—Will Ladislaw***

"Because receptor technology is vitally important in developing drugs that can be targeted against specific diseases, it receives high priority in our R&D effort."

Anthony A. Sinkula
Director, Drug Delivery Systems Research
Upjohn

"All drug companies recognize that receptor technology is the way to develop new drugs, particularly for central-nervous-system applications."

Teena L. Lerner, VP
L. F. Rothschild, Unterberg, Towbin

A computerized image of brain tissue receptors is displayed at Upjohn's Kalamazoo, Mich., laboratory, a leading research facility for disorders of the central nervous system.

Across the industry, receptor technology is expected to gradually team up with computer-aided design techniques to develop new drugs more quickly and economically.

cal—are not nearly so clear.

Nevertheless, RT is seen as an important new "enabling technology" that in some cases could speed the development of other research tools. Although chemists are already using computer-aided design in drug development, for example, they must first build databases on receptor shape and activity—a task that could be made simpler and more accurate with RT methods.

An important future avenue is the development of RT assays in tissue culture (the practice of artificially growing and maintaining large clusters of specific cell types in a lab). Unlike isolated cells or bits of tissue extracted from an animal or a human cadaver, the cultures will provide receptors in a more natural condition on their cell surfaces; the cells of interest can then be selected to isolate the desired receptors into a more homogenous mixture. The cultures may also provide simple tests for drug interactions with receptors and their net effects on the body—tests such as SKF's leukotriene assay, which monitors muscle-cell contractility.

Because receptors are proteins, genetic engineering could also shed new light on recognition site techniques. "Molecular biology and recombinant DNA technology have made protein analysis much simpler," says Norman Weiner, vice-president of pharmaceutical discovery at Abbott Pharmaceuticals (North Chicago, Ill.). "Analyzing receptors through their amino acid sequences will be a giant step forward." And as researchers become more proficient in these analyses, it will become easier to construct large quantities of specific receptors; these proteins could then serve as "templates" for new drug molecules, and as the bases for simpler, more precise binding assays.

The potential value of RT extends far beyond pharmaceuticals. The growing understanding of receptors will help explain how living cells interact with nondrug molecules (toxins, for example), and how cells and other organisms are attracted to one another. It may even provide important new clues about how and why malignant cells cluster and propagate, and how those life-threatening processes can be disrupted.

Such inquiries may still be years away, however. For the pharmaceutical industry, RT has already proved itself an invaluable tool. "Receptor technology is one of medicine's most promising commercial disciplines," says NIH's Axelrod. "It's the wave of the future in new-drug design." □

Roger S. Johnson, who holds a PhD in biochemistry from the Univ. of Illinois, writes frequently on biotechnology.

For further information see **RESOURCES**, *p. 69.*

COMPUTERS IN SCHOOLS: CAN THEY MAKE THE GRADE?

The U.S. must remedy outdated hardware, inadequate software, and poor teacher training

by Margie Ploch

Education in the United States has become a matter of serious concern. To help students learn faster and better, most schools have turned to computers. But so far, U.S. schools have bought only one computer for every 50 students—about 750,000 machines—according to Quality Education Data (QED), a market research firm in Denver. Worse yet, the machines are often poorly used, many are vintage models that run slowly and have very little storage, and most of the software just isn't very good.

There is still room for optimism. "Because computers are interactive and respond to each student's needs, they offer a tremendous opportunity to improve the educational system," says Alfred Bork, director of the Educational Technology Center at the University of California at Irvine. But to succeed, administrators and software developers must unravel a tangled knot of technological, economic, and educational problems.

Technology issues. According to QED, more than 55% of schools own Apple computers (most of them in the Apple II family), 17% own Radio Shack models, and 13% own Commodores. The majority of these machines have limited memory—often as little as 64 kilobytes—and 8-bit microprocessors, thus restricting the educational software they can run. Trying to fit a complex educational program into a microcomputer with 64 kilobytes of memory is like "trying to park a

limousine in a tiny garage without scratching the paint," says Virginia Gemmell, director of research and design for Spinnaker Software (Cambridge, Mass.). And because an 8-bit microprocessor can address less memory than a 16- or 32-bit chip, it runs programs more slowly and has more rudimentary graphics. This "produces a substantial amount of constraint," says Judah L. Schwartz, director of the Educational Technology Center at Harvard University. "But if I want to do something in the schools today, I need to do it on 8-bit machines."

As a result, the older microcomputers are often used with simpler, less creative education programs or with general-purpose productivity tools that were not specifically designed for school use. However, Schwartz maintains that software developers can encourage schools to purchase 16-bit machines by writing high-quality programs for them. If schools want the software badly enough, he believes, they will buy the advanced hardware.

As schools acquire micros with faster processing speeds and more memory, they might add multimedia peripherals such as videodiscs and compact disc read-only memories (CD ROMs). But "it's important to remember that the market is conservative and moves slowly," says Anne Paterson, a marketing

The U. of California's Alfred Bork sees computers as "a tremendous opportunity to improve the educational system."

DANIEL A. FORT

manager for Apple. "It's hard enough to get teachers to use the computers they have now."

Other developers favor a more aggressive approach: "We need an integrated delivery technology for education," says Thomas Anderson, executive vice-president of Commonwealth Strategies Consulting (Boston) and director of two multimedia projects in cooperation with WNET, New York's public TV station. Anderson envisions a digital television set with an optional internal 32-bit microcomputer and ports for CD ROM and other peripherals. Within three years, Anderson predicts, such a system should be available for about $2500.

Some schools are already taking an integrated approach, and experimenting with advanced technologies as well. For example, the Houston school district uses speech synthesis in an innovative 45-disk program for teaching English as a second language. Houston's success in using synthesized voice has encouraged Apple to undertake, with the school district, the development of a reading program for grades K through two that combines computer exercises, voice output, and print materials, says Apple's Paterson. Spinnaker Software has incorporated voice in two reading programs, and Scholastic (New York) is developing a word-processing program capable of reading aloud anything a child types on the screen.

Software developers are also investigating the role that artificial intelligence may eventually play in education. "What schools need," says Patricia Sturdivant, Houston's associate superintendent for technology is systems "that can diagnose individual learning patterns and generate appropriate activities." An intelligent tutor program could fill this role, says John Seely Brown, a researcher at Xerox's Palo Alto Research Center. It could then analyze the students' responses and lead them to discover and correct their errors. Artificial intelligence techniques could also allow educators to create software that helps students to learn as if they were apprentices to a master. These programs would combine the attractiveness of open-ended discovery environments with the control of more traditional learning situations.

Windows on the world

A promising type of educational software is the simulation, a program that can approximate a real process, system, or event, allowing a student to, say, conduct a chemistry experiment, set up a new business, or run for president of the U.S. Such programs can help students learn how processes work, improve their reasoning skills, and get a feeling for history. "With simulations you can do things you ordinarily wouldn't get a chance to do with a textbook or in a traditional class," says Robert Strickland, a resource teacher and computer specialist with the Broward County, Fla., school district.

Simulations are difficult and expensive to write, because of the many interrelated variables they involve. As a result, say Strickland and other educators, there aren't many good ones; indeed, simulations represent only a small portion of educational programs. In New York state, for example, only 10–15% of the programs used in English, math, and reading are simulations (the rest are problem-solving programs, tutorials, and drill-and-practice programs). Simulations are most prevalent in science and social studies, where they account for 27% and 42% of the programs used.

In science classes, simulations enable students to do experiments that would be too costly, too dangerous, or simply impossible to perform in a school laboratory. Schools that can't afford a chemistry lab or biology lab can give their students simulated experiences using software, says Greg Benson, director of the New York State Center for Learning Technologies. With Operation Frog from Scholastic (New York), students can dissect a frog; with Chem Lab from Simon and Schuster (New York), they can make chemical compounds. Some educators caution, however, that simulations should not replace all experience, because students need to learn the physical skills necessary for working in a lab.

In addition to making such experiments possible, simulations give students greater control over processes than they might have in reality. For example, students can stop a reaction in midstream, or alter variables and repeat the experiment as often as they want. Instead of simply reading about abstract concepts, students can manipulate them, says Samuel Gibbon, executive director of the Voyage of the Mimi project at Bank Street College (New York). Discover from Sunburst and Discovery Lab from the Minnesota Educational Computing Consortium (MECC) in Minneapolis each simulate a biology laboratory. By collecting data, then forming and testing hypotheses, students can find the conditions under which organisms will thrive. They can do similar things with programs that model ecosystems and animal behavior, such as O'Dell Lake and Oh Deer (both from MECC), T.rex and The Honey Factory (both from Keron Productions in New York), and the Island Survivors program in Voyage of the Mimi.

Other simulations focus on problem-solving techniques, instead of real situations. In The Factory from Sunburst Communications (Pleasantville, N.Y.), for example, students analyze manufacturing processes. They learn how three simple machines work, how to create parts, and how to set up an assembly line to build a finished product. A new version of this program, The Super Factory, creates 3-D objects for the child to match. Robot Odyssey from The Learning Company (Menlo Park, Cal.) includes simulations of electronic circuits and simple robots. To escape from a maze, players must apply what they've learned about electronic circuits to reprogram robots so that they can avoid the danger in each room. Students learn not only how to build an electronic circuit but also how to analyze a problem, break it into parts, and systematically solve it.

History simulations recreate the human side of the subject, instead of just teaching dates and facts, says Strickland. In Oregon Trail from MECC, students join a wagon train bound from St. Louis to Oregon. (According to Greg Benson, this program probably represents a large portion of the simulation use in social studies in New York state.) The difficulty level of the program depends on how much money the player is allowed to spend on food and equipment for the journey. Players also decide what time of year to start their trip, what supplies to buy, whether to buy food or hunt, and whether and what to trade with other travelers, among other things. Those who plan poorly or fail in emergencies die on the trail. In order to cover the scenario and variables, the program fills six disks.

President-Elect from Strategic Simulations (Mountain View, Cal.) and 2088 from Scholastic each simulate a presidential election in which the student candidate's decisions on policy issues affect his or her chances of winning the election. The Whatsit Corporation from Sunburst puts students in charge of a one-product business. First they organize and finance the company, then they run it—deciding on such factors as the size of their sales force, the amount of inventory, and the price of the product.

Economic issues. Writing high-quality software, even for 8-bit computers, is expensive. For example, a simulation program (see "Windows on the world") might cost up to $500,000 to develop, says Kenneth Komoski, executive director of the Educational Products Information Exchange (EPIE) in Stony Brook, N.Y. Good curriculum software, designed to work with a semester or year-long course, can cost $1–1.5 million, says Anne Wujcik, program director for Talmis. High costs, she says, result in part from the need for a development team—a need that has grown in the past two years as graphics have become more important in educational software. A typical team might include an instructional expert, a subject-area expert, a graphics specialist, a music specialist, and a programmer.

"Fitting a complex program into a 64k computer is like trying to park a limousine in a tiny garage without scratching the paint."

When developers combine computers with other media, costs rise even higher. Voyage of the Mimi, developed by the Bank Street College of Education (New York) and distributed by Holt, Rinehart & Winston (New York), is a science package that includes software simulations, cassettes of a TV show of the same name, and print materials. The video segments introduce concepts, which students can later explore and manipulate through software. For example, an interactive model of an ecosystem allows children to change variables and see the effects.

Producing such a project is "expensive, complicated, and time-consuming," says Samuel Gibbon, executive director of the project at Bank Street.

Bank Street software developer Samuel Gibbon (right) exchanges views with New York state learning technologist Greg Benson at a computer conference held last May by Lesley College, a teacher-training institution in Cambridge, Mass.

NED MCCORMICK

Development funds for Voyage of the Mimi will ultimately amount to $8–9 million, says Frank Withrow, leader of the technology applications group in the U.S. Department of Education's Office of Educational Research and Improvement. The Department of Education and the National Science Foundation will have provided about 80% of the money, he says.

Since 1981, however, the federal government has failed to mandate that Department of Education funds be spent on the use of technology in education, says Withrow. Much of the money invested in educational technology has come from the secretary of education's discretionary fund ($12 million out of a budget of $17 *billion*) and the block grants made to states. So most of the money for software development comes from the private sector, an arrangement that often results in higher costs and fewer projects that are intellectually (and financially) daring.

The school software market is "fairly small but steady," with sales of $130 million in 1985, growing to $150 million in 1986, says Talmis's Wujcik. "It probably won't grow more quickly," she adds, "until the software is more compelling." Individual programs for the school market typically cost about $50, with some discounts for multiple purchases. Thus a district with 1000 micros might pay roughly $20,000 to outfit all its computers with a single program.

As a result, some developers allege, educators are illegally copying their programs. To solve this problem, certain companies are adopting site licensing schemes, in which the school district pays a single fee to use a program on all its computers. For example, Logo Computer Systems International (Montreal) is marketing its Logowriter program (see "Tools for schools") through site licensing.

Educational issues. Even the best software may founder in the classroom if the teacher isn't trained to use it. The real obstacles in implementing educational technology, says Houston's Sturdivant, are "not hardware or software but peopleware."

As a result of its experiences when testing Voyage of the Mimi in classrooms, Bank Street College started training teachers in computer use. "No matter how good the materials are, they're useless if teachers are uncomfortable with them," says Gibbon. "But in classrooms where teachers are comfortable with computers or science—or even just with their ignorance—the materials work like gangbusters." In the same spirit, Apple Computer has given scholarships to 10,000 teachers for taking courses on integrating computers into the classroom. But these and similar programs have reached only a fraction of the nation's 2 million teachers. And the U. of California's Bork argues that such brief workshops are inadequate for producing teachers who truly understand educational uses of computers.

Even teachers skilled in using computers may be overwhelmed by the task of selecting software. With more than 7000 programs to choose from, teachers can't possibly assess them all. Not even software review groups such as EPIE, the Northwest Regional Educational Laboratory (which runs a software evaluation project called Microsift), the National Education Association (Washington, D.C.), and state consortia have been able to evaluate all the available programs.

To help teachers find software that complements state curricula, California has sponsored the Technology in the Curriculum project, matching high-quality software (as recommended by EPIE and Microsift) with four major areas of study—language arts, history/social studies, science, and math. Other groups are undertaking similar projects: EPIE, for one, has matched the software it has reviewed with topics in elementary school math.

For their part, developers are supplementing their software with documentation that tells teachers how to incorporate the programs into their regular lessons. For example, Sunburst's SemCalc, a program that helps students solve word problems, comes with a list of exercises in 27 textbooks that students can work on with the program.

But will matching programs with curricula allow teachers to get the most

Tools for schools

Productivity tools, notably word processors, spreadsheets, and databases, are selling well in schools—from first grade to twelfth. Moreover, the number of teachers who see computers as tools for applications, such as writing, solving problems, or analyzing data, has increased during the past two years, according to the preliminary report on the second annual survey of the instructional uses of microcomputers. (This study was conducted by Henry Jay Becker at Johns Hopkins University in Baltimore.) Perhaps the main reason for the popularity of such tools, says Patricia Sturdivant, Houston's associate superintendent for technology, is that they can be used for administration as well as teaching. Apple, for example, sells its AppleWorks, an integrated software package, as a tool set for students, teachers and administrators.

Many vendors have designed or modified productivity programs especially to suit students. The Bank Street College of Education (New York), for example, developed Bank Street Writer (distributed to schools by Scholastic and to homes by Borderbund of San Rafael, Cal.), and Sunburst Communications (Pleasantville, N.Y.) wrote Magic Slate. Homework Helper/Writing from Spinnaker Software (Cambridge, Mass.) is a word processor with a tutorial that prompts students to organize their thoughts before they begin writing. Children spend more time on their writing when they are using word-processing programs than when they are struggling with paper and pencil, says Virginia Gemmell, Spinnaker's director of research and design. Just as word processors help students with the mechanics of writing, so spreadsheets and databases can aid them in compiling data in science classes.

Some companies are combining scholastic productivity tools with other programs to make both more effective. Logo Computer Systems International (Montreal), for example, has paired a word-processing program with Logo, a graphics-oriented programming language developed by MIT's Seymour Papert, a long-time advocate of computers in education. Logo is widely used in schools for teaching computer literacy, programming, and problem solving. The program, called LogoWriter, should appeal to teachers who require pupils to write about their Logo projects.

Similarly, Scholastic has modified a widely accepted series of tool programs—PFS:Write, PFS:File, and PFS:Report from Software Publishing (Palo Alto, Cal.)—and published it under its own name. In addition, the company has created several curriculum databases with which students can use the tools. Using the databases on U.S. history and government, for example, students can retrieve information needed for a social studies paper. Other subjects are life sciences and physical sciences, literature and composition, poetry and mythology, and world geography and cultures. MECC (Minneapolis) and Grolier (New York) likewise supply curriculum databases for use with their productivity programs.

Educational software: slow but steady growth

A wide range of software is currently available for teaching elementary and high school–level skills and concepts with computers. The market for such products is potentially huge, since almost all the 80,000 schools in the nation have at least one computer. But this market has been relatively small compared to that for business software, a condition likely to prevail for the next few years, according to Anne Wujcik, program director at the Talmis division of Link Resources (New York). She estimates the school software market at $150 million this year, increasing to $300 million by 1990.

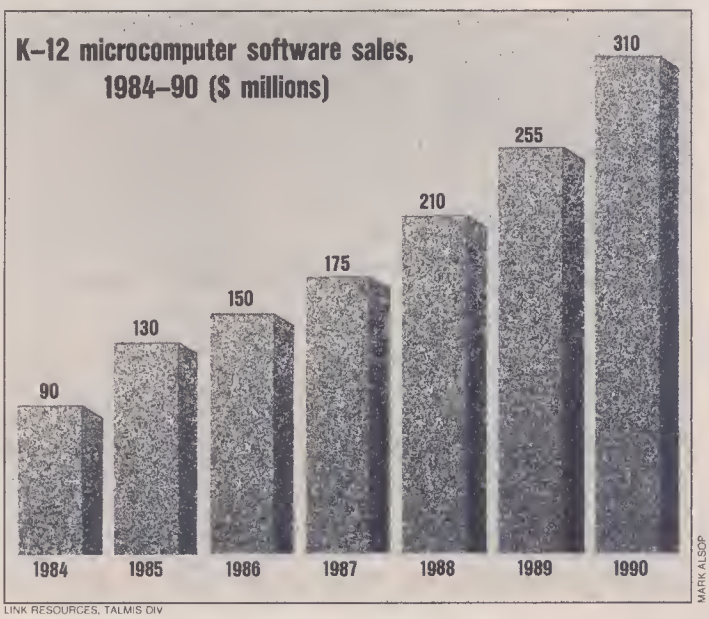
This market is fragmented among a variety of firms based in such sectors as hardware manufacturing, textbook publishing, and software production. Major players include Scholastic Software, Random House, and Holt, Rinehart & Winston (all based in New York); Apple Computer (Cupertino, Cal.); Scott, Foresman's Southwestern Publishing (Cincinnati); Milliken (St. Louis); Broderbund (San Rafael, Cal.); Sunburst Communications (Pleasantville, N.Y.); and the Minnesota Educational Computing Consortium (Minneapolis). Many of these firms distribute their own products as well as educational software developed by independent producers.

"The supply of pedagogically sound software has improved dramatically over the past three years," says Wujcik. "You no longer see factual or logical errors in programs, or ill-suited graphics." However, says Wujcik, programs still have a long way to go. "There is not yet enough high-level, exciting software available that moves beyond multiple-choice drill-and-practice routines to offer training in a variety of skills or advice of a tutorial nature," she says. "But publishers will hesitate to produce such software until they are confident that high development costs can be recouped through school purchases."

"Would anybody publish textbooks if each school bought one book and made whatever additional copies it needed? That is why the educational software market is growing so slowly."

Carol Bunevich
Director of Marketing
Scholastic Software

The current pattern of software sales can be characterized by several recent developments. "Schools are no longer buying software indiscriminately, or settling for stand-alone programs that cannot be integrated with the daily work schedule of teachers," says Marie Terry, computer marketing manager at the Webster Division of McGraw-Hill. "Now, schools are asking us to slot software into the curriculum to match appropriate skills needed by students at various levels." Such programs are often matched closely with textbooks and may come with statements of learning objectives, lesson plans, tests, teacher aids, and workbooks that students can use in conjunction with computer activities. Large textbook publishers have an advantage in marketing this type of software, as they can piggyback sales on top of their traditional product ties to school districts.



At the same time, interest has grown in application software that may not have been developed with educational purposes in mind. A majority of school software funds are now being spent on these products, reports Wujcik. "Such programs need not be tied to any particular textbook, although teachers are still looking for subject matter relevance," says Carol Bunevich, director of marketing at Scholastic. "We are particularly known for developing curriculum-oriented data files and associated material for use with general-purpose database management and word-processing programs."

Many teachers are also drawing on discretionary funds made available by most districts to buy software on their own. This has opened an additional window to schools, beyond direct purchases by districts, for companies primarily oriented to developing educationally related programs for the home. Such firms include Spinnaker Software (Cambridge, Mass.), Davidson & Associates (Torrance, Cal.), The Learning Company (Menlo Park, Cal.), and Broderbund.

"The school market is expensive to crack," says Seth Godin, manager of new products at Spinnaker. "Products need a lot of support, including in-service training and presentations to boards of education. And in the end, school districts may not buy a lot of copies." So his company decided to develop relatively inexpensive game-oriented educational software aimed at consumers but also usable in schools. Godin estimates that Spinnaker software accounts for at least half of the home market for such products.

"Teachers who are into computers know they can get our software at local computer retailers and in some stores that specialize in teaching supplies," says Godin. "Once we get one program into a school, interest in our product line spreads by word of mouth. Apple originally got its hardware into schools in this manner; we are following the same route."—***Dennis Livingston***

out of computer-based learning? Most programs at present are stand-alone packages, limited in scope by technology and by the assumption that they will serve as adjuncts to textbooks. This is not enough, according to some educators, who want developers to shoulder the task of integrating software and other materials to cover full-scale courses. For example, says the U. of California's Bork, a computer simulation might be only a tenth of the material in a course involving a variety of approaches and media. To be effective, he says, a simulation needs to be surrounded by other ways of learning about the subject—such as problem solving and drill and practice—so that it is put into context.

Not all educators agree. Instead of being tied to a particular curriculum, says Harvard's Schwartz, software should be sufficiently flexible to work with any course in a particular field. Schwartz has designed a series of programs called the Geometric Supposers, which he claims accomplishes this goal for teaching plane geometry. The programs lead students to formulate and explore their own ideas about geometry, says Schwartz. Whether targeted for a specific curriculum or a more generalized "domain," good educational software is both difficult and expensive to create. Therefore many educators believe it can be accomplished only by a national initiative in software development and curriculum reform. The needed intellectual and financial resources are simply not available on the local level, says Schwartz.

One proposal, by William Honig, California state superintendent of public instruction, calls for federal and state governments to invest $1 billion—half a percent of the $200 billion dollars a year spent on education in the U.S.—in technology-oriented curriculum development, including computer software. He believes the U.S. Department of Education should spearhead this project. Meanwhile, the state of California is seeking private-sector partners for major curriculum development projects, according to Wendy Harris, manager of the state's Education Technology Unit. Another proposal, by the U. of California's Bork, is for a national experiment to develop 20–30 full-scale computer-based courses, together with computer-based training for teachers on how to use the materials. Extensive testing of

One proposal calls for federal and state governments to invest $1 billion in technology-oriented curriculum development.

10,000–100,000 students would compare the curricula for each subject area with each other and with traditional methods of teaching that subject. If the six-year trial went well, says Bork, he'd propose that the U.S. revise all curricula for grades K through 12, with three or four courses in each subject so that schools could choose among them. Such a project, he says, would require sizable funding from the federal government as well as support from state governments and the private sector.

Although Schwartz agrees that the federal government must become involved in curriculum development, he points out that different people have different notions about education and that curriculum reflects educational ideology. A national curriculum development project must therefore find ways to permit ideological diversity.

Despite such calls for federal support, the Reagan administration prefers to leave development to the marketplace, says the Department of Education's Withrow. Moreover, he says, states want to control education without federal interference. Thus Withrow and others have recommended to the Task Force on Technology in the Schools (instituted by the National Governors' Association) that states form consortia to finance and administer major development projects. In August the task force will issue its final report, which is expected to include specific recommendations to the states.

Although there may be some differences in emphasis from state to state in curriculum areas, says Greg Benson, director of the New York State Center for Learning Technologies, there are basic similarities. If several states—say, 30–40% of the market—could agree on a curriculum for a fully integrated course with the necessary administrative tools for teachers, they could represent an economic force to which publishers would respond. The states of New York and California are now reviewing their curricula to see if they have enough common ground to work out a shared curriculum. If they think it's worthwhile, says Benson, they will invite other states to participate. "Educators will have to work together to make it happen."

Patricia Sturdivant (right), head of the Houston school district's department of technology, works with a computer graphics specialist to design instructional software.

But success is by no means assured. The question that many educators, parents, and community leaders are posing is not "Can we do this?" but "Will we choose to?" The U. of California's Bork answers such hesitancy with another question: "Is education really a national goal, or do people merely want to pretend it's important?" □

Margie Ploch, a freelance writer, is former managing editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 69.*

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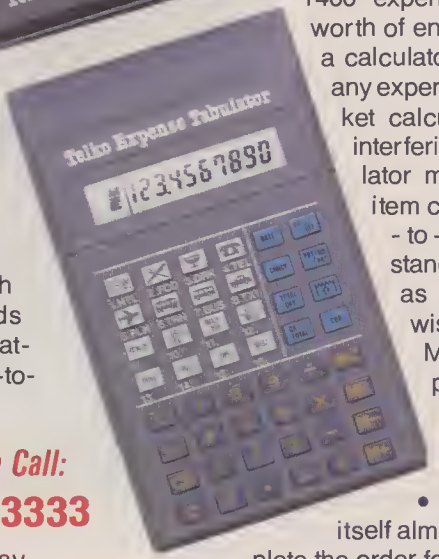

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COMPACT DISCS ON THE GO

Mobile units that are small and rugged may give tape decks a run for their money

On the market little more than three years, the digitally encoded compact disc (CD) seems to have caught the recording industry off guard. Despite hefty prices, there aren't enough CD releases to satisfy consumer demand for the laser-scanned discs' pristine sound. Now—even before CDs have established market supremacy over long-playing records in the home environment—players in automobile and personal portable versions are beginning to mount what may prove to be a serious challenge to cassette tapes for mobile listening.

The entry of CDs into these fields was spearheaded by Sony, which jointly developed the CD format with Philips. Sony introduced optical discs into the automobile in 1984, and early last year, into the realm of the personal portable—a category it had also pioneered with its Walkman line of headphone-equipped, pocket-size radios and tape players. Sony's first personal portable, the D-5, was also the first CD player of any kind priced as low as $300. Indeed, many buyers use portable CDs as inexpensive *home* players.

But as even less expensive home players have become available, the mobile CD is gaining ground in its own right. There are now at least eight makes of personal portable CD player, and a similar diversity of CD "boom boxes." Automobile CD players, many of them combined with radio tuners, are being marketed under at least 12 brand names. Philips makes an automobile CD player that can be removed from its in-dash housing for use as a personal portable.

For CD players to work in such demanding environments, they had to be made smaller and more rugged. One of Sony's critical moves was to shrink the optics assembly to about a third of its size in home players. The focal length of the player's objective (focusing) lens—the distance the laser beam must travel so it arrives at the disc as a pinpoint of light—usually determines the unit's size. Sony overcomes this constraint by "folding" the optical path; mirrors send the light on a zig-zag journey through a smaller volume.

Another space saver was the substitution of a very-large-scale integrated circuit, containing the equivalent of 30,000 transistors, for three less densely packed chips used in Sony home players. The result of Sony's space-saving measures is a 1½-inch-thick

Already weighing less than 2½ pounds, portable CD players are shrinking to the limit imposed by the size of the disc itself.

SETH RESNICK

by Art Zuckerman

box with a 5 × 5¼-inch cross section—barely larger than the disc itself. Sony has incorporated essentially the same mechanism into a boom box that includes CD player, AM-FM radio, cassette tape deck, and detachable speakers.

It's crucial in any CD player to make sure that the laser beam stays focused and on track. Most players use some kind of multibeam technique. Sanyo, for example, splits the laser output into three beams, each of which bounces off the disc and falls on a separate photosensor. The main beam reads the audio track, while the other two beams deviate slightly to either side of the main beam. If tracking is accurate, the light reflected by each side beam is equal. Any imbalance in side-beam pickup is identified as a tracking error. Logic circuits figure out the direction and degree of error, and instruct a servomotor to correct the position of the laser/optical assembly.

Soon after Sony introduced the D-5, Matsushita brought out an even smaller player that scans the disc with a single beam. This player, marketed under the Technics label, compares the intensity of the reflected beam across a 2 × 2 array of photodetectors. An off-track beam results in a left-right imbalance. Misfocus gives the reflected beam an elliptical cross section, so that more light falls on one opposing pair of corner elements than the other. As in the multibeam system, deviations generate a signal that drives a lens-moving motor.

Space is saved because this four-element package is more compact than the three separate sensors used in other players, and because there's no need for a beam-splitting element. To further cut the number of components, Matsushita designed a single lens to do a job that normally takes two lenses: straightening out the laser's slightly divergent output and then focusing the beam into a tiny point on the disc. The same portable design has been incorporated into boom boxes and car CD players sold under the Technics and Panasonic names.

Keeping the player stable under shock and vibration is a problem for any mobile CD player. Matsushita suspends its single-lens optical assembly on four wires anchored to rubber grommets in the player's chassis; a spring-loaded mechanism smooths movement of the laser pickup on its guide rail. In another mechanical solution, Yamaha mounts all the internal circuitry and mechanical parts in its YCD-1000 automobile player on soft rubber connectors. Sony's second-generation model, the D-7 Discman, keeps the pickup steady by attaching it to a rotating, weighted belt that resists sudden changes in direction the way a gyroscope does. In Pioneer's automobile units, sudden acceleration triggers a special circuit to memorize the present position of the laser/optic scanner on the disc; when the jolt is over, the optics assembly is restored to its original position.

Another important concern in the automobile is sheer handling of the compact disc. Extracting it from its jewel-box container generally takes both hands to avoid damaging the disc. Yamaha's solution is a lightweight plastic cartridge carrier that slips into the player's loading slot. Load up a couple before you start a trip, and you're all set. Blaupunkt, JVC and Clarion use similar systems.

Disc-scanning lasers stay on track with gyroscopes and acceleration sensors—even through jarring potholes.

But leave it to Sony to come up with the most spectacular solution, a 10-disc changer called the Discjockey. A high-impact, dust-resistant housing that contains the changer mechanism and electronics is installed in the trunk of the car. A cable extends into the passenger compartment, terminating in a remote-control "commander" unit that can be mounted on the dash or left loose for riders to pass around. At the beginning of a trip, the system's 10-disc magazine is loaded and slipped into the changer in the trunk. Any selection on any disc can be randomly selected, and up to 10 selections from the various discs can be programmed in any sequence.

The Discjockey is designed to accommodate the special problems of car audio. For example, one of the CD's main advantages—its dynamic range, or ability to reproduce an extremely wide range of loudnesses—is generally of limited value in an automobile. Therefore the Discjockey has a control for reducing dynamic range, which helps make even a faint flute solo audible amidst the omnipresent rumble of the road. In addition, the disc changer is mounted on a free-floating suspension that isolates it from shock. According to one independent test report, driving over cratered streets and even railroad crossings did not affect performance. But at $1000, Discjockey costs almost twice as much as standard in-dash CD players.

At the lower end, inexpensive accessories enable personal portables to be used in cars. Sparkomatic (Milford, Pa.) offers a $20 adapter that plugs into the player's headphone output and transmits the signal to the car's radio antenna. For the same price, Recoton (Long Island City, N.Y.) offers a unit that slips into a cassette player in place of a tape; the device takes electronic signals from the CD via a cable plugged into the headphone jack and converts them into varying magnetic fields, thus simulating a moving tape.

The impact of portable CD players on the audio cassette industry will probably be less dramatic than the effect home CD players are having on phonograph records, however. Because of the size of the disc itself, even the smallest CD player is bulkier than a personal portable cassette deck. Nevertheless, compact disc players' sheer accuracy and their freedom from audible distortion should make them increasingly popular with listeners on the go. The Electronic Industries Association (Washington) predicts that total CD player sales will soar from this year's 1.8 million to 2.3 million in 1987. And, says analyst Harold Vogel of Merrill Lynch (New York), "there's every indication that portable and automotive players will be a solid niche in the growing CD market." □

Art Zuckerman is a freelance writer living in Rochester, N.Y.

MAKING PLANES FROM POWDER

Tough alloys that stand up to heat may soon replace heavier materials in many aircraft

Aerospace designers have traditionally been reluctant to trust powder metallurgy—the formation of parts by pressing and heating metallic powders in molds. They have worried that the technique would introduce impurities, voids, or foreign particles that would generate cracks in manufactured parts. But new techniques for producing contaminant-free powders, which yield formed metals with spectacular resistance to high temperatures and corrosion, are allaying these fears. The result: a wider choice of materials to fill tough aerospace needs.

Manufacturers are already taking advantage of the options. Boeing (Seattle), for example, is testing powder-metallurgical aluminum in landing-gear forgings for its 757 wide-body jet. Its high compressive strength saves about 15% on weight, offsetting its 50% greater cost.

The capabilities of powdered metals stem from the basic principles of metallurgy. An ordinary metal part is a mass of interwoven crystals (called grains) that typically contain flaws (called dislocations). When the metal is stressed—by bending it, for example—the dislocations move within the grains, allowing rows of metal atoms to slide past each other. As a result, the metal deforms, or yields.

Quenching or alloying can minimize such deformation. Hot metal quenched by being plunged into water cools rapidly, producing small grains. Since the dislocations cannot travel far in such grains, the metal resists yielding. Quenching, however, often makes a metal brittle or hard to form. In alloys, small quantities of added elements, such as carbon in steel, control dislocations. The extra elements form tiny inclusions in the grains, which act as barriers to the motion of dislocations. But certain sought-after compositions may be impossible to achieve through the traditional means of forming alloys; the additives may separate out, refuse to dissolve in the matrix metal, or dissolve only in limited quantities.

Powder metallurgy can achieve a fine-grained microstructure directly. Each grain of powder acts as if it were a tiny crystal. The manufacturer can thus control the grain size independently of any heat-treating process. And mechanical alloying, in which powdered ingredients are mixed at low temperatures, overcomes most restrictions on alloy compositions.

There are several techniques for preparing powders. Reducing a metal slab to sawdust by grinding it is the simplest, but because of the limitations of mechanical tools, this produces relatively coarse powders. "Splat-cooling" provides much better control: molten metal is extruded onto the chilled rim of a rotating wheel, which cools it instantly into a thin ribbon. The ribbon is chemically treated with hydrogen, which makes it brittle enough to grind easily into a fine powder. Heating the powder then drives off the hydrogen. The Plasma Rotating Electrode Process, developed by Nuclear Metals (Concord, Mass.), shows even more promise. The raw metal is shaped into a cylinder that rotates at 10,000–30,000 rpm and serves as an electrode. An electric arc melts the spinning metal, which throws off molten droplets in an inert atmosphere of cool helium. As their temperatures plummet thousands of degees in a few milliseconds, the droplets condense into "rapid solidification powders" so fine that they approach an amorphous state, in which atoms arrange themselves in formless patterns rather than freezing into ordered crystals.

This approach has reached the stage of market feasibility. After spending

MARKO MATERIALS

In splat cooling, molten metal (here an iron-based alloy) is poured onto a rotating wheel. It solidifies into a thin ribbon that is pulverized into powder.

by T. A. Heppenheimer

about $30 million on the process over the past 10 years, "we now view rapid solidification as an established technology," declares Philip Parrish, manager of powder metallurgy at the Defense Advanced Research Projects Agency (DARPA) in Arlington, Va. "This technology now can stand alongside such traditional methods as ingot casting or drop forging."

Completing what rapid solidification has started demands a method of consolidating the metallic powders. Hot isostatic pressing, or HIP, is a common technique. The powder is compressed in a mold for several hours at an elevated temperature. This causes the grains to sinter (weld together) into a material without internal voids or holes. A vacuum pump draws off gaseous impurities that cling to the grains' outer surfaces.

Temperature resistance benefits significantly from powder metallurgy. Conventional aluminums can rarely withstand temperatures much above 350° F: a "high-temperature" alloy from Alcoa, for example, has a barely acceptable tensile strength of 25,000 pounds per square inch (psi) at 500°. By contrast, a powder-metallurgical alloy of Alcoa's that contains 8% iron and 4% cerium possesses a strength of 50,000 psi at that temperature. Alcoa expects this alloy to remain usable up to 600°, allowing it to compete with the more costly standard titanium alloys. Those alloys, in turn, cannot stand up to temperatures beyond 700–900°. But using rapid solidification, McDonnell Douglas (St. Louis) has raised titanium's limit to 1100° and hopes to go considerably higher. "We're shooting for 1500," says company materials scientist Michael Callaghan.

Powder-metallurgy titanium offers other advantages. At certain temperatures, its alloys can possess such high ductility that parts can be formed by gas pressure instead of by forging or machining. Sheets of this "superplastic" titanium can be draped over a form almost as if they were cloth. Such superplastic forming reduces waste, because it allows parts to be formed nearly in their final shape with minimal machining, and hence a minimum of metal cuttings. Ceramic-mold processes also help. Here, the part is shaped in wax or plastic and then coated thickly with ceramic, which forms a mold. The wax or plastic is then melted, leaving the mold ready for use. Engine-mount supports that Nuclear Metals makes by this method for the Navy's F-18 fighter have a "buy-to-fly" ratio of about 2 to 1: the raw material is roughly twice as heavy as the final part. With conventional methods, the ratio is 15.5 to 1.

Turbines for jet engines are frequently made from nickel alloys. Often called superalloys, they can stand temperatures as high as 2200° F. However, this excellent high-temperature strength makes the superalloys difficult to forge or form. Powder metallurgy has again come to the rescue, replacing such methods as casting and forging, and offering both lower manufacturing costs and up to 50% savings in input materials.

Rapid solidification powders will be pressed into service for the airframe of the X-30—the research airplane due to fly into orbit in the mid-1990s. Conventional design approaches would have used nickel alloys for temperature resistance, but rapid solidification titanium can do the job at half the weight. The result, according to studies by contractors, could be a craft that carries the payload of the Space Shuttle but weighs a fifth as much at takeoff. That could be the real payoff of the new materials derived from powder.

For now, development teams are studying how best to convert powder metallurgy principles into products. General Electric (Schenectady, N.Y.) and Marko Materials (Billerica, Mass.) are developing iron- and nickel-based alloys made from powders. The Cabot Corp. (Boston) is exploring nickel alloys. Teams at the Air Force Materials Laboratory at Ohio's Wright-Patterson AFB and the University of Wisconsin are working with powder titanium, and Lockheed (Burbank, Cal.) is studying titanium-beryllium alloys.

Aluminum manufacturers have already begun marketing powder products. An alloy called P/M 64, made by Kaiser Aluminum (Oakland, Cal.), has 4.5 times the stress resistance of conventional alloys. Alcoa (Pittsburgh) offers corrrosion-resistant aluminum alloys formed by powder metallurgy that are 32% stronger than their conventional counterparts cast as ingots.

Alcoa sees opportunities for its new products beyond aerospace. The company is trying to interest shipbuilders in using powder-metallurgical aluminum for the hulls of high-speed ships. Unlike ordinary aluminum, the powder form does not lose strength by cracking in seawater. □

T. A. Heppenheimer, a freelance writer based in Fountain Valley, Cal., has a PhD in aerospace engineering.

Carbon-carbon: the hotter the better

Another new material—tough, lightweight, and nonmetallic—has emerged for aerospace uses that demand high strength at high temperatures. Carbon-carbon composite, which consists of carbon fibers in a matrix of carbon, has joined powder-metallurgy titanium as a realistic alternative to the nickel superalloys that for decades were the only feasible materials for mechanical parts operating at temperatures above 1000° F.

Carbon-carbon currently serves such applications as the nose and leading edges of the Space Shuttle—uses in which it stands up to temperatures above 3000° but requires little mechanical strength. By contrast, new forms of carbon-carbon are strong enough to serve as turbines, which develop temperatures as high as 3500°. "Carbon has a very interesting property," explains Robert Williams of DARPA, who directs the National Aerospace Plane program. "It gets stronger the hotter it gets, up to the point where it oxidizes—at which point your whole structure vaporizes. As long as you can prevent it from oxidizing, by using suitable coatings, you get the increasing strength."

With support from DARPA, LTV (Dallas) and Garrett Turbine Engine (Los Angeles) are carrying out a $45 million Air Force contract to develop carbon-carbon as a structural material for advanced jet engines. LTV has fabricated a 15-inch-diameter turbine wheel with 36 blades and has successfully tested it at 40,000 rpm. At 7.5 pounds, it weighs just a fourth as much as a turbine made from superalloys.

The raw material for carbon-carbon is woven fabric of polyacrylonitrile fiber, which resembles rayon. This fabric is impregnated with a pitchlike resin and then heated and pressed, causing the material to carbonize and to sinter together. The final step is to apply an oxidation-resistant coating. Besides LTV, suppliers of carbon-carbon include Union Carbide (Cleveland), Hercules (Magna, Ut.), and HITCO (Gardena, Cal.).

KEEPING SPREADSHEETS UNDER CONTROL

Add-on programs and careful documentation can reduce errors in complex files

Spreadsheets have become the most widely used business application for microcomputers, surpassing even word processing in corporate America. The attractions of spreadsheets are obvious; you can enter numbers and formulas in a ledgerlike format in an easy, intuitive way and quickly see results that reflect an existing business situation or a future projection. Even beginners now forsake the back of an envelope for computerized efficiency.

The problem is that spreadsheets are almost too easy to use; you can build up a complex structure in a few minutes, but is it correct? Business school students may soon study the case history of the first company that went bankrupt because its spreadsheet models had errors—and no one realized it until too late.

Spreadsheets are really manageable only up to the size you can comfortably conceptualize in your head—about two ledger pages or so. Larger spreadsheets are much harder to keep track of, and the big sheets many users brag about are impossible to understand without exceptional discipline or special tools. (There are exceptions to this size guideline: for example, simple models extending over a long time period, such as many years' worth of monthly sales, or long lists set up as a database.)

Of course, many spreadsheet models are too complex to fit into two pages. Such models should be broken down into smaller parts, each of which stays within the two-page limit. The smaller sheets should then be consolidated as entries on a master spreadsheet, which itself is no more than two pages long. Unfortunately, Lotus 1-2-3, which dominates the spreadsheet market for the IBM PC and clones, cannot adequately perform consolidation—the gathering of information from several files automatically. Information can be moved manually, but you must remember to perform this step every time you use your data. Software with true consolidation ability, such as Multiplan, Framework, and Excel, automatically checks all subsidiary files for the latest data whenever you load the master spreadsheet.

The lack of consolidation has driven 1-2-3 users to create ever-larger spreadsheets; such users were the driving force behind the Lotus-Intel-Microsoft Expanded Memory Specification. EMS is a clumsy hardware patch that increases the memory available for data and has the unfortunate side effect of encouraging still larger and more unmanageable spreadsheets.

Because sloppy spreadsheet work is all too easy, in many companies only one or two master users can change the underlying formulas.

You can—actually, you must—keep careful notes of what you are doing while you construct a spreadsheet. Turner-Hall's Note-It lets you attach a text file to a 1-2-3 cell to document your work. (Personics' Smart Notes applies a similar idea in a more general way, letting you add notes to most text-based programs, not just 1-2-3. But Smart Notes doesn't work effectively with spreadsheets because notes are not tagged to a specific cell; consequently, if you change or move a cell, you lose the note.)

The easiest way to use 1-2-3 and other spreadsheets gets you into the most trouble. Most users merely use cell addresses (such as C3, B4) in formulas that might read K6=B4+C3. These tags are hard to understand; more careful users give names to every variable so a formula will read Cost of Loan =Principal+Interest. (Within 1-2-3, you should at least employ the Text Formula function so the formula will read B4&"Principal"+C3&"Interest".) But with very complex spreadsheets, it is all too easy to get lost. Careful analysis requires printing out the formulas and checking cell by cell—and repeating this process when you modify the spreadsheet. A 1-2-3 accessory program, Spreadsheet Auditor, helps by displaying cross references and keyboard macros along with a cosmetically improved formula printout.

Because sloppy spreadsheet work is all too easy, many companies consider important spreadsheets so critical that only one or two master users can change the underlying formulas; everyone else works on copies.

Another solution is to change to alternate software such as Javelin, a program that forces users to work in a relatively precise way. Although Javelin has a spreadsheet-like mode, it works mainly with structured models in which you define the formulas with named variables. Such models are much harder to use, however, since they lack a spreadsheet's fluidity of operation. The latest Javelin version can read and write 1-2-3 files, so a company might use 1-2-3 for casual work and Javelin for serious, formal work.

Despite the many actual and potential problems, 1-2-3 remains a powerful and appealing product; the problems often arise through misuse rather than from inherent faults in the program. Of all the spreadsheets that have entered the marketplace, only 1-2-3 has been adopted almost universally, leading to scores of supporting books, training courses, and add-on programs.

SQZ, for example, reduces 1-2-3 files to less than a fifth the usual size, which is useful for floppy disk systems and particularly for telecommunications (a compressed, pure ASCII file format option permits files to be sent via text-only services such as MCI Mail). QuickMac eases the often tedious process of creating 1-2-3 macro commands.

More elaborate supporting programs extend 1-2-3's functions. Although what-if questions are easy to

by Cary Lu

Companies

Ashton-Tate (Framework), 20101 Hamilton Ave., Torrance, CA 90502, (213) 329–8000

Consumer Software (Spreadsheet Auditor), 8315 Monterey St., Gilroy, CA 95020, (800) 645–5501; in CA: (800) 556–6699

Fox and Geller (Passkey and AutoMac), 604 Market St., Elmwood Park, NJ 07407, (201) 794–8883

General Optimization (What's Best), 2251 N. Geneva Terr., Chicago, IL 60614, (312) 248–7300

Javelin, One Kendall Sq., Bldg. 200, Cambridge, MA 02139, (617) 494–1400

Lotus (1-2-3), 50 Commercial St., Cambridge, MA 02142, (617) 577–8500

Microsoft (Multiplan and Excel), 10070 Northrup Way, Box 97200, Bellevue, WA 98004, (206) 882–8080

Personics Corporation (Smart Notes), 2352 Main St., Concord, MA 01742, (617) 897–1575

Turner-Hall Publishing (Note It and SQZ), 10201 Torre Ave., Cupertino, CA 95014, (408) 253–9607

ask on a spreadsheet, finding the optimum values for variables is ordinarily a trial-and-error process; What's Best employs linear programming to calculate the optimum values. 1-2-3 has some database features that are easy to set up although limited in function. Lotus's own Report Writer adds output formatting to the spreadsheet, but Borland's Reflex is a complete database that sells for the same price as Report Writer and offers much more power along with 1-2-3 file compatibility.

In its current form, 1-2-3 is showing its age. It was, after all, designed at a time when most computers could not display graphics and 256 kilobytes was considered a large amount of memory. Two Macintosh products show the direction of new spreadsheets. Compared with IBM Personal Computer products, they work better and are far easier to learn and use. Lotus's Jazz integrates spreadsheets and business charts with word processing, and Excel offers the most functions and power of any spreadsheet thus far. Products with such power and ease of use will slowly begin to appear on the IBM PC. Since the 1-2-3 file format has become a de facto standard, current users should be able to move to improved products easily—if they are sure that their current spreadsheets are valid. □

Cary Lu is microcomputer editor of HIGH TECHNOLOGY.

VIDEOCONFERENCING EXPANDS ITS HORIZONS

As lower-speed and still-picture systems emerge, the market is opening up

Although videoconferencing has long captured the public's imagination, it has yet to capture much of a market. Part of the problem can be attributed to high equipment and transmission costs, and to a shortage of high-speed transmission networks. Beyond that, the true benefits of videoconferencing have sometimes been overlooked. But activity in the videoconferencing market is heating up, and many observers expect the technology to gain widespread acceptance in the coming years.

Because it permits people separated by wide distances to meet electronically, videoconferencing has always been promoted mainly as a way to cut travel expenses. Its primary benefits may lie elsewhere, however. While videoconferencing *can* serve as an alternative to travel, "the cost benefit is more a productivity issue than a savings in travel expenses," says Ann Earon, president of Telemanagement Resources International, a consulting firm in Short Hills, N.J. Busy executives or engineers can participate in meetings by walking to on-site videoconferencing rooms or, in some cases, can even link into meetings via terminals on their desks. "If I'm paying someone $100,000–$250,000 a year and I have to take that person out of their job and send them to a distant location for a two-hour meeting, I'm certainly willing to install hardware, keep the person on-site, and let them be more productive," says Earon.

by Sam Diamond

Traditionally, the term "videoconferencing" has been taken to encompass all the technologies that enable a group to have an interactive conference with clear sound and sharp, full-motion video pictures. Such quality of service usually requires the use of "T1" transmission links, which carry voice and image data at 1.544 megabits per second.

While T1 links still provide the highest-quality service, the market has expanded to include systems that operate over 56-kilobit-per-second networks. Some of these lower-speed systems employ desktop picture phones that transmit limited-motion video images, while others retain the approach of placing cameras, microphones, and video monitors in a designated conferencing room. In either case, the relatively slow transmission speed means that less information gets packed into the video transmission, so some picture quality is sacrificed.

Luma Telecom's desktop phone displays freeze-frame images sent via regular phone lines.

At the low end of the market (or, as some contend, in a different market entirely) are freeze-frame conferencing systems and camera-equipped desktop units, which transmit still video images over standard 9600-bit-per-second telephone lines. While unable to satisfy customers seeking to simulate the feel of face-to-face meetings, freeze-frame systems can accommodate certain applications for which the more expensive 56-kilobit and T1 systems would represent overkill.

Given the breadth of videoconferencing available and the variation in customers' applications, some reputable vendors insist that a needs assessment be completed before they sell their systems to prospective clients. "There is no definitive study that says people must have video for best communication; it comes down to personal preference and the needs of the company," says Jeff Charles, a research fellow at the Institute for the Future (Menlo Park, Cal.). "If a majority of the people interviewed during the assessment say their meetings involve visually oriented tasks—they show draft documents, line graphs, or color images, or discuss product dimensions—then some form of video is probably beneficial."

Videoconferencing is also useful for conducting business in which body language speaks louder than words. "Groups of executives who want to talk to another group of managers at another location tend to feel a real need to see the people they talk to, and are usually willing to spend the bucks for a full-motion video room," says Telemanagement Resources' Earon. "On the other hand, if meetings mostly occur in small groups that are more concerned about new product designs or other graphic representations,

they don't need to see faces."

At the heart of full-motion T1 and limited-motion 56-kilobit systems—the two systems used for face-to-face conferencing—is the codec, or coder-decoder, a device that converts the analog video signals to a digital format and compresses them for economical transmission. At the receiving end, an identical unit decodes the digital signals and puts them back into an analog format for display on a video monitor. Every manufacturer of codecs uses its own proprietary algorithm for the coding, rendering different codecs incompatible with one another. While vendors talk of standardization, there is no sign of a near-term solution. Codec prices range from about $60,000 for a 56-kilobit device to over $100,000 for a T1 model.

T1 codecs are the undisputed Cadillacs of the industry. Because the transmission speed is so great, compression is minimized and picture quality remains high. As transmission speeds decrease to 56 kilobits per second, however, video signal compression increases, and picture quality usually decreases, particularly when a subject moves. Compression algorithms sample the analog video signal, leaving out some bits of information. In reconstructing the signal, they extrapolate from the retained data to intelligently guess what is missing. A "smart" algorithm might produce a better-quality signal than a higher-speed but less intelligent compression algorithm. But since higher speed usually means better quality, T1 videoconferences are really the "next best thing to being there," although the costs are high.

Besides the high-priced codec, total costs for a full-motion T1 system depend on the number and quality of cameras and monitors used, the sophistication of the audio system, the presence or absence of a high-resolution graphics transmission facility for conveying quality graphic images through an input/output port in the codec, facsimile equipment that transmits graphics along separate lines, and various bells and whistles such as elaborate podiums and room furnishings. Vitalink Communications (Mountain View, Cal.), a videoconferencing system integrator, offers a complete T1 system for $120,000, including codec, audio, camera, and monitor. For this comparatively low cost, however, the user sacrifices graphics transmission capability, and reduces the maximum number of conferees to five at each end.

Vitalink's full-motion systems can simultaneously display meeting participants as well as objects under discussion.

More expensive systems (the average Vitalink T1 system sells for $175,000) can comfortably accommodate six to eighteen people, offer higher-quality components, high-resolution graphics capabilities, and simple push-button controls. These systems also display all meeting participants on two adjacent screens; cheaper systems display two rows of people on one screen in a format frequently referred to as "Hollywood Squares."

While a typical 56-kilobit codec costs about $40,000 less than its T1 counterpart, the difference in complete system costs tends to be even greater. Both types of systems require cameras, monitors, audio, and graphics, but "there is a perception that since the quality of 56-kilobit transmissions is not as good as T1, the systems should cost far less," says Larry Levy, director of videoconferencing at Vitalink. So 56-kilobit vendors "tend to use lower-quality components and cameras, and smaller screens."

But the real cost differential between T1 and 56-kilobit systems is in transmission rates. For T1, transmission costs are currently as high as $750 per hour, while 56-kilobit transmissions cost just $50 per hour. Despite this discrepancy, some companies may find T1 comparatively economical, particularly if they already have T1 lines in place for other communications applications. The reason is that although nationwide long-distance 56-kilobit networks are available through AT&T, MCI, and Argo Commu-

nications, local 56-kilobit switching to reach the long-distance networks is offered by the Bell Operating Companies only in certain cities. Currently, San Francisco, Minneapolis, Chicago, Milwaukee, Columbus, Boston, New York, Los Angeles, and Indianapolis offer such service. Companies in other cities must either pay for expensive links to the nationwide networks or lease or buy an earth station for satellite transmissions.

To connect Vitalink's offices via a 56-kilobit line to San Francisco 40 miles away, says Levy, would require a three- to five-month waiting period and a monthly bill of about $1100. Satellite earth station costs are lower, but still high. A typical dish costs about $45,000 to buy or $900 a month to lease for five years.

Nevertheless, local phone companies throughout the country have announced plans to offer 56-kilobit service, and equipment vendors are counting on its becoming widespread. PicTel (Peabody, Mass.), for example, has recently come out with a 56-kilobit codec that can either be used in a conference room setting or be incorporated into a desktop unit for communications between two people. A complete PicTel videophone system costing $150,000 includes five desktop terminals, a local-area network that connects the terminals within a building, and the codec. For off-site transmissions, of course, another $150,000 would have to be spent to install a system at a different location. Still, over the next five years the system price should be reduced to under $50,000, according to Randy Smith, vice-president of marketing for the company.

The PicTel system is not just for one-on-one meetings. Since both desktop and full-conference 56-kilobit systems utilize the same codec, the PicTel units can be used to dial into a conference, allowing a busy individual the option of attending a meeting without leaving his or her office. This feature is not possible with T1 systems, because no desktop units are yet available at the high transmission speeds.

Even with this benefit, though, 56-kilobit systems have their problems. In particular, the picture becomes blurry if conferees move around a lot. "If you have eight people in a videoconference who are all irate over some forecast being discussed—and they're jumping up and down, beating on the table, and walking around—you just took a gun to the head of a 56-kilobit codec. It simply can't handle it," says Fentress Hall, vice-president of marketing at Compression Labs (San Jose, Cal.), a T1 codec manufacturer that claims to have captured more than 70% of the U.S. market.

If 56-kilobit systems can sometimes falter in their full-motion transmissions, freeze-frame systems dispense with them entirely. Such systems transmit over standard telephone lines, and because they require from several seconds to a few minutes to transmit an image, the systems are inappropriate for conferences where eye contact and nonverbal cues are important. The price of a system is $5000–$25,000, depending on component quality, on whether the system is a conference room arrangement or a desktop unit, and on whether transmissions are in color or black and white—a cost-saving option not available with full-motion systems, because the savings would represent only a tiny percentage of the system price.

Videoconferencing is useful for conducting business in which body language speaks louder than words.

Desktop freeze-frame systems are particularly suitable where field personnel need assistance from off-site experts. If, for example, a field repair person has a problem with a piece of equipment, he can set up a picture phone and send images of the equipment back to a conference room where staff engineers can help him solve the problem. One company employing such a system boasts that "when our repair people go into the field, the eyes of the company are behind them."

Freeze-frame is also useful if conferences center on blueprints, diagrams, designs, or the like. And by incorporating an audio conferencing bridge, people at multiple sites can talk about the same displayed images. Nevertheless, the technology remains unpopular, and is often not even classified as a videoconferencing technique. "Our society has grown up on television, so psychologically it is hard for many individuals to contemplate what still video can do," explains Cynthia Keen, marketing manager of teleconferencing products at Colorado Video (Boulder), a leading manufacturer of freeze-frame equipment

For many it is just as hard to contemplate the future direction of videoconferencing. Just when the technology seems about to stabilize, some new product rocks the boat. For example, Concept Industries (Stamford, Conn.) has announced the development of a codec—due on the market in about a year—that president William J. Tobin claims will be "10 times cheaper and 10 times better" than anything currently available. The technology will enable a standard personal computer to be converted into a receiving videoconferencing terminal for less than $6000, he says. In other configurations, it will be able to transmit and receive at a range of speeds, both above and below 56 kilobits per second.

The availability of inexpensive desktop units of high quality might well be the stimulus that videoconferencing needs to make it a popular technology. "With lower component prices and low-cost 56-kilobit service, we can get good-quality video on people's desks for as little as $100 a month in one to two years," says Vitalink's Levy. "For desktop video to become widespread will require another three to four years, but this is the year it will start to take off." □

Sam Diamond, a freelance writer based on Long Island, N.Y., specializes in business and technology subjects.

SIMULATING THE FACTORY

Software helps avoid costly mistakes—before equipment is installed

Even the most careful planning of highly automated, computer-controlled manufacturing systems sometimes fails to prevent major design blunders—robot arms that collide, automatic guided vehicles that pile up in traffic jams, or part feeders that run out of inventory too soon. To avoid costly mishaps, industry is turning to a computer-modeling specialty called manufacturing simulation.

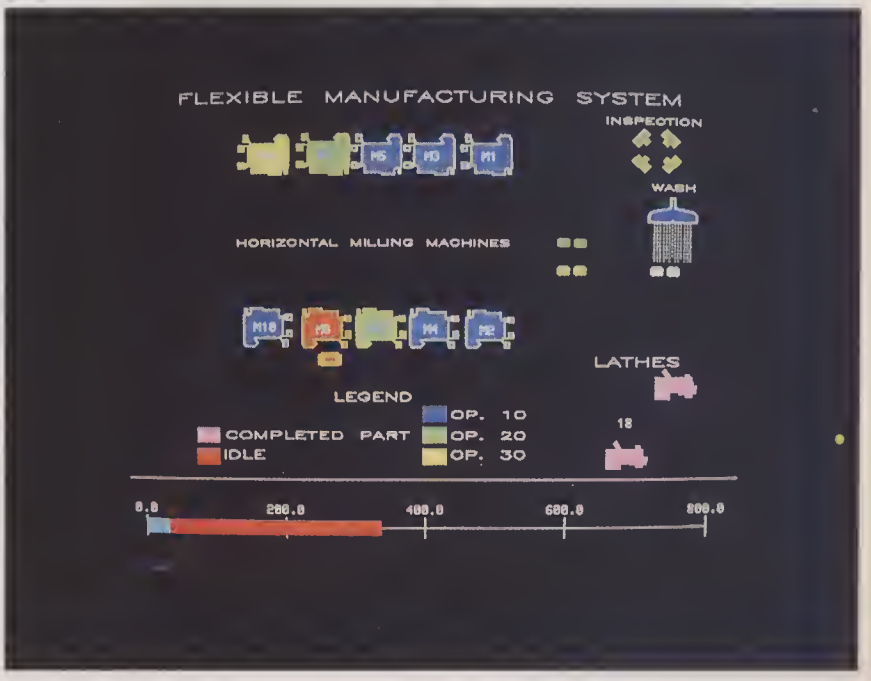
Using specialized software, simulation predicts and displays the movements and interactions of a manufacturing system's components. By evaluating the placement, pathways, and operating parameters of equipment before it is purchased or installed, industrial engineers can avoid pileups, bottlenecks, and other malfunctions, reducing the time and expense of starting up new manufacturing operations. Thus simulation is proving most beneficial for complex automation projects like multiple robot installations and flexible manufacturing systems. Also benefiting from simulation are materials handling and process control operations. Primary users so far are automobile makers, especially General Motors and Ford, but manufacturers like aerospace and appliance companies are also getting into simulation.

Their interest is spurred by new developments that make manufacturing simulation easier and less costly. Early programs were restricted to use by a few specialists, since the simulated results were entangled in arcane statistical tables that required expert analysis. But the recent addition of color graphics and animation "has caused an explosion in the use of simulation," says George E. Griffith, an operations manager at EDS (Troy, Mich.), a General Motors subsidiary that does simulation consulting for industrial clients.

What's more, the newer, more user-friendly systems are encouraging many manufacturers to perform simulations in-house, rather than relying on consultants. This is expected to boost sales of simulation software to about $90 million annually by 1990, a sizable jump from last year's estimated $14 million in sales, says Richard K. Miller, author of a report on manufacturing simulation for SEAI Technical Publications (Madison, Ga.). On the other hand, the growth of manufacturing-simulation consulting services will be slower, reaching $90 million in annual sales by 1990, compared with 1985's estimated $50 million sales level, according to Miller.

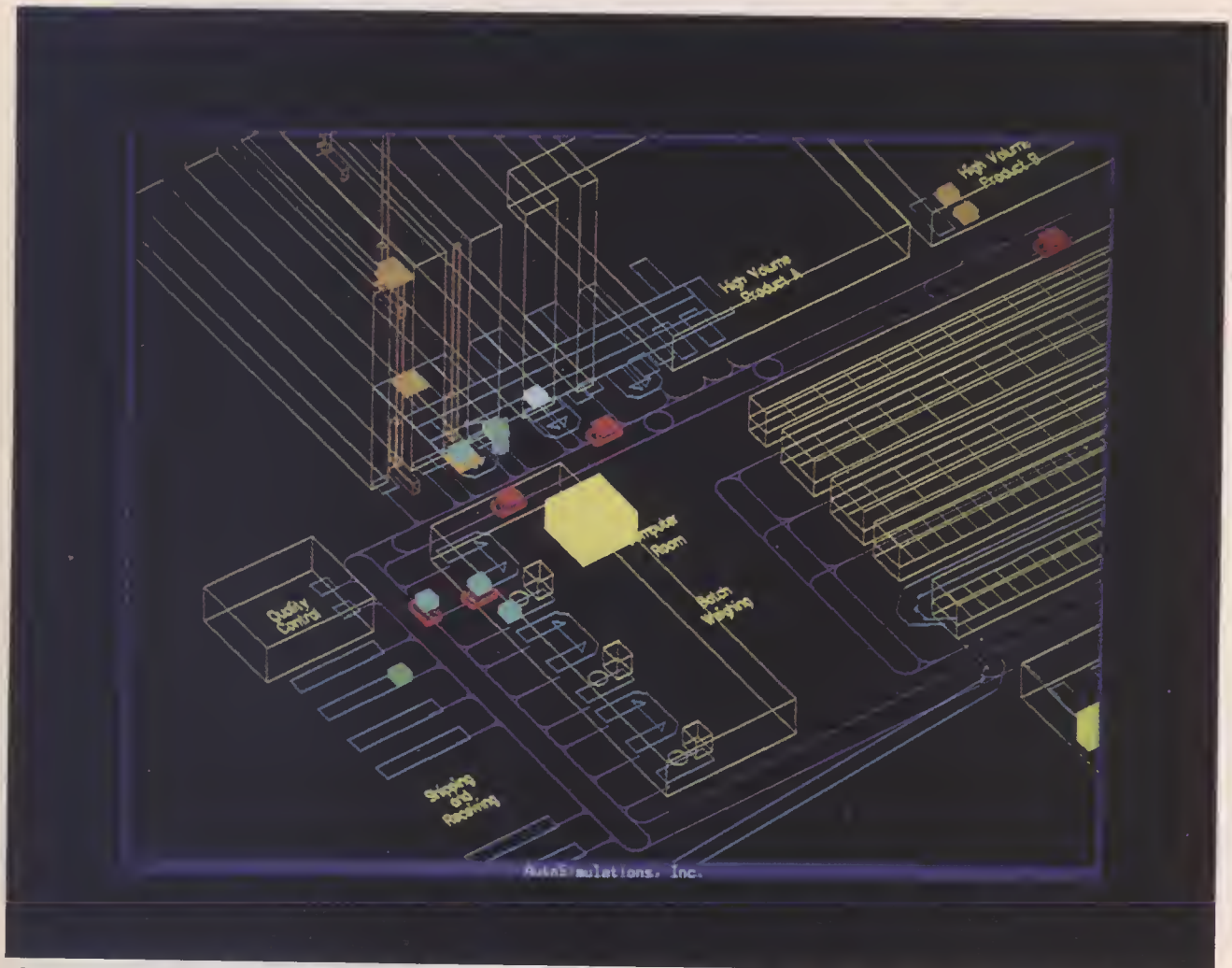
About three dozen vendors offer simulation software, ranging in price from a few hundred dollars to more than $10,000. The lowest-priced packages can run on a microcomputer such as the IBM PC; more elaborate systems require a minicomputer or mainframe. Many vendors also provide simulation consulting.

While each application differs, simulation programs follow similar general procedures. At a computer workstation equipped with a digitizer tablet (an electronic table connected to a plotting pen for locating points on the terminal screen), the designer "draws" three-dimensional models of each system component. Then the models—either wireframe line drawings or "solid" representations—are assigned their proposed positions within the system being simulated. Next, the engineer manipulates on-screen symbols, called icons, to program the pathways and movements of equipment such as robots, automatic guided vehicles or machine tools. Finally, performance parameters are typed into the system; these include factors like the speed, reach, and weight-lifting capacity of robot arms, processing time at each workstation, and material-handling time between locations.



A simulation on Pritsker & Associates' TESS software shows 10 milling machines performing one of three operations, identified as operations 10, 20, and 30 and individually color-coded. Elapsed time is shown in bar at bottom.

by Gordon Graff



The traffic flow of automatic guided vehicles (in red, with their pathways marked in purple) in a simulated flexible manufacturing system is shown in an AutoSimulations program.

With the model now built, the designer runs the program to see the physical motion of the proposed system. The engineer can also improve the design of the manufacturing system by on-screen tinkering, like moving some of the machines or changing the sequence of parts delivered to an assembly center.

Aside from these basic similarities, simulation packages vary widely in their features. Some present statistical analyses only, some stand alone, and others are bundled with a computer-aided design and manufacturing (CAD/CAM) package. Some model the motion of discrete components only, while others can portray the behavior of an entire factory. They also use widely different programming languages that the user must master for setting up a simulation, ranging from Fortran to a more user-friendly, near-English language.

For example, the SLAM II program of Pritsker & Associates (West Lafayette, Ind.), which uses Fortran, can model the behavior of large manufacturing networks or discrete events, but produces only statistical readouts (other P&A products provide animation). GE Calma (Santa Clara, Cal.), a General Electric subsidiary, offers a robot-oriented program called Robot-Sim. Users can design a work cell, simulate a robot's motions in the cell, and then modify the robot's movements and placement of surrounding machinery for optimum performance. Design is aided by libraries of performance data on widely used robots and equipment. The Automod program of AutoSimulations (Bountiful, Ut.) models complete factories, warehouses, and distribution centers, by means of a user-friendly language. A companion program, AutoGram, includes graphics to illustrate the system and animation to demonstrate its motion.

Other leading suppliers of simulation software include Systems Modeling (State College, Pa.), McDonnell Douglas Automation (St. Louis), Silma (Los Altos, Cal.), Intergraph (Huntsville, Ala.), Computervision (Bedford, Mass.), Hutchinson Associates (Milwaukee), General Electric Automation

Controls Division (Charlottesville, Va.), CMS Research (Oshkosh, Wis.), Panasonic Industrial Equipment Division (Secaucus, N.J.), CACI (La Jolla, Cal.), HEI (Carol Stream, Ill.), Prab Robots (Kalamazoo, Mich.), Roboticad (Birmingham, Mich.), and Horizon Software (Waltham, Mass.).

Manufacturers are reporting significant savings in cost and time due to simulation. At a General Electric assembly plant in Louisville, Ky., for example, GE Calma modeled the behavior of a robot that was to remove metal dishwasher-lining panels from a rack, place them in a bed for drilling and testing, and then transfer them to a conveyer. With simulation, engineers optimized the position of the testbed and conveyer relative to the robot and prevented the robot from exceeding its carrying capacity—performing in minutes "what might take five to ten hours to do on the factory floor," says GE Calma consulting engineer Scott Borduin.

At Ford Motor's new plastic-bumper facility in Milan, Mich., engineers working with AutoSimulations software were able to solve a costly problem before it arose, says Alan D. Heneveld, a supervisor at the plant. Simulation showed that a plan to improve performance in the bumper molding operation resulted in too many of the facility's automatic guided vehicles shuttling empty through the automatic storage and retrieval system. Hence, in order to optimize overall equipment use, Ford slowed down the molding step.

At Exxon, an in-house program to simulate gasoline manufacturing, blending, storage, and shipping operations saved $1.4 million in its first application nine years ago, according to Lewis B. Golovin, associate adviser in Exxon's communications and computer sciences department. Since then, he reports, the program "has increased significantly in scope, power, and use." It has been applied to 30 major studies throughout the company, saving "tens of millions of dollars per study." In one case, Golovin says, simulation showed a major mismatch in design capacities between parts of a proposed plant. If the plant had been built with the flaw, it would have been restricted to only 50–60% of capacity because of hidden bottlenecks, he reports.

Improvements being developed for simulation programs promise to make them even more powerful tools for industrial engineers. Automatic programming not only suggests the best performance parameters for a robot in a particular application, but also programs the actual robot when simulation is complete. Another coming feature, optimization, eliminates the need to run large numbers of trials to find the best configuration for machines. An optimization feature would allow the computer to run through the possibilities automatically.

Also under development is emulation, a feature that enables the computer to simulate the actual inputs and outputs that might occur during factory operation. This brings the model much closer to actual operating conditions and provides information unavailable through conventional simulation. Consequently, emulation is expected to be a valuable tool in debugging control system software.

Although simulation is still largely a stand-alone tool, the trend is to integrate simulation into related industrial engineering software. After about 1990, predicts SEAI's Miller, "when you buy your CAD/CAM package, simulation will be part of it."

These enhancements notwithstanding, industry watchers caution that the growth of simulation might be hampered by the myriad of different languages now used in commercial programs. Protecting their proprietary interests, most suppliers of simulation still use unique languages that are generally not interchangeable with different hardware. Only programs using a common language like Fortran are "transportable" between computers. But Fortran is hard for the neophyte to master. The interim solution, believes Miller, is an industry-wide standard language. But, he adds, "I believe we will get to the point where natural languages such as English work well on computers; then we won't need standardization because everybody will start speaking English again." □

Gordon Graff, a New York–based writer, is a former senior editor of HIGH TECHNOLOGY.

PERSPECTIVES

AI for chip designers: testing the untestable

"Unsolvable" is the word used time and again by engineers describing the problems of testing very-large-scale integrated (VLSI) circuits. While computers can design such chips as 32-bit microprocessors and 256-kilobyte random-access memories, there has been no way to assure that these conglomerations of 100,000 or more transistors will do what they are supposed to when stamped into silicon.

The only way to know whether a circuit works is to send digital patterns—series of *0*s and *1*s—into it and compare what comes out against the logical design. This method of testing has two limitations. First, it's an enormous task just to choose, out of the billions of possibilities, a set of test patterns that will uncover faulty logic in the least time. Second, even when a fault is detected, it is difficult to determine where the defect lies within the vast network of logic gates and microtransistors.

But now, techniques of artificial intelligence are being applied to the task, with encouraging results. Texas Instruments (Dallas), for example, is developing a system to help generate the minimum set of test patterns that will reveal the circuits' flaws. Working from a schematic layout of the chip, the Texas Instruments program identifies circuit paths that would conceal flawed transistors during fault simulation. By first setting aside such "invisible" faults for manual analysis, the TI system substantially reduces the time it takes to run the automated fault simulation.

So far, the program has been tried only on sections of circuits containing a few dozen transistors. It currently checks about 1500 transistors per hour, a rate that would take over two days of nonstop analysis on a typical VLSI circuit. TI engineers Stephen Lusky and Thirumalai Sridhar, who developed the system, expect to boost that rate to 50,000 transistors per hour by the end of the year through new programming techniques and a faster version of Prolog, an AI programming language. Such a rate, says Sridhar, would bring the fault detection system much closer to commercial viability.

In another approach, GenRad (Milpitas, Cal.) has devised a program making "testability" an IC design rule, in the same manner as traditional design rules govern more tangible features like minimum transistor size. The program might, for example, stipulate that the chip include circuit paths with no function other than to provide additional points for checking the chip's operation—essentially, "windows" into the chip. Thus testers can obtain more information about the chip's internal workings than they can by monitoring the limited number of output leads.

GenRad's system is composed of three artificial intelligence programs, all with the same base of rules and circuit configurations. The first program checks whether each section of the circuit is testable. Then an editor program replaces as many noncompliant sections as it can with testable sections from its database. Another program uses the design rules and the circuit model to generate a set of test patterns.

VLSI's complexity also hampers testing of printed circuit boards made from these chips. Because of the complex interaction of the many VLSI components on a board, a single defect—say, an IC lead that has shorted to ground—can cause a board to fail many tests, leaving the technician with a morass of failure messages that often obfuscate, rather than pinpoint, the problem. Teradyne (Boston) has developed an expert system to weed out spurious failure messages and prepare a precise set of instructions for repairs. System designer Larry Apfelbaum describes the knowledge base as a collection of common sense and expertise contributed by Teradyne's customers and in-house board repair specialists. A software-based inference engine draws on the knowledge base the way an experienced technician would. The system uses its "experience" to sift through failure data to find the one test that indicates a genuine defect.

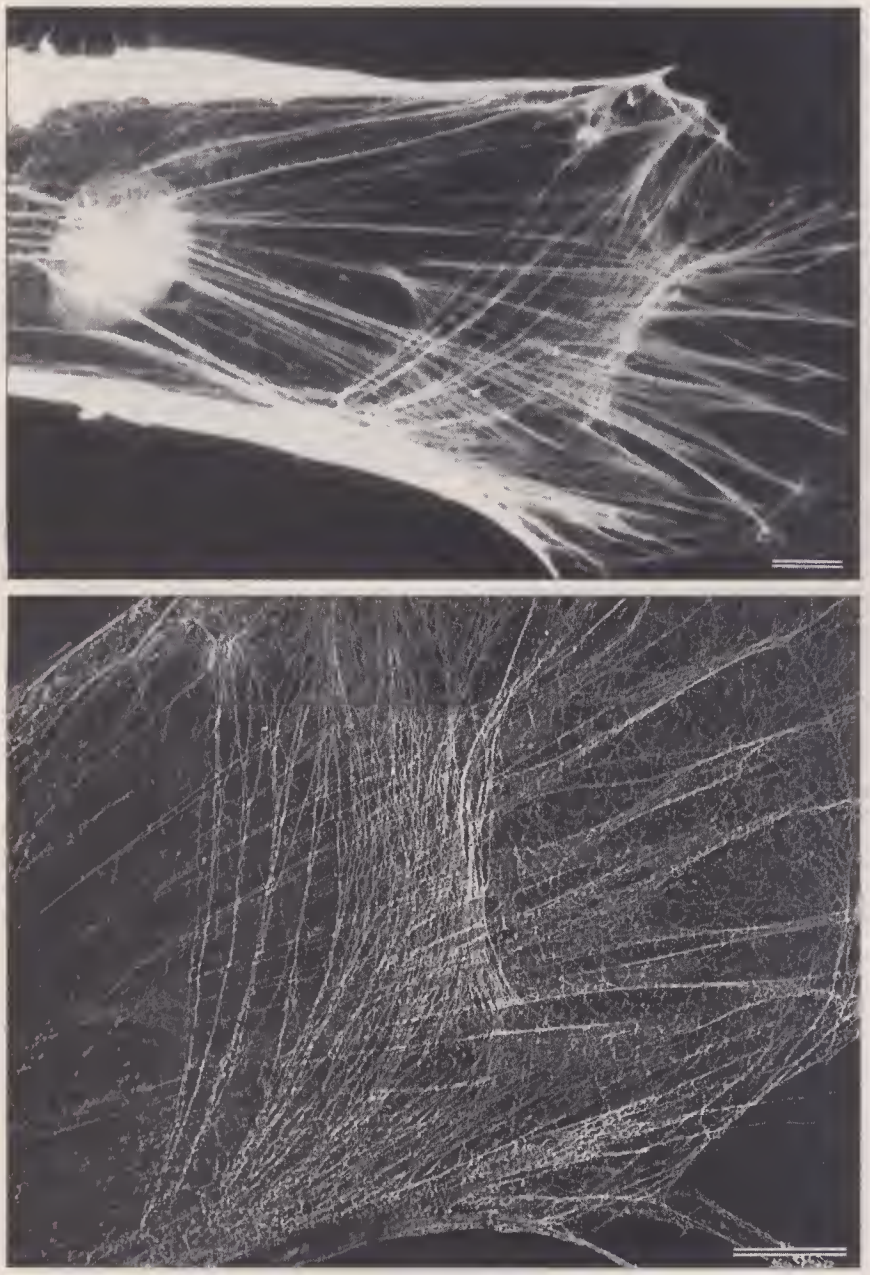
The importance of such expert shortcuts grows with chip complexity. As the circuits become larger, they are both more expensive and more susceptible to damage during removal. Thus repair mistakes become much more costly. "Even if today's boards failed at the same rate as two years go, the cost of repair would go up exponentially," says Apfelbaum. "So you want repair messages that are short and accurate."

Present chip-testing systems use artificial intelligence only peripherally—TI uses it to prevent the computer from wasting its time on undetectable flaws, while GenRad's system makes circuit designs more "transparent." But ultimately, AI could do for chips what Teradyne does for boards—infer exactly what is wrong with an IC design by examining the faulty output of a test pattern. □ ***—Brad Fisher***

UV microscope could aid biology, electronics

Researchers at the University of Oregon and Portland State University are developing a new type of microscope that combines the advantages of a technique called immunofluorescence optical microscopy with the enlarging capability of an electron microscope. Although the device is still being refined (and still limited to biological research work at Oregon), it could ultimately become an important new analytical tool for the electronics and medical technology industries. The apparatus—called the photoelectron microscope, or PEM—uses ultraviolet (UV) light to make the target object emit electrons; the particles are then focused and processed into an image that may be filmed or viewed on a monitor.

Conventional immunofluorescence microscopy is a widely used diagnostic technique that reveals the presence of a molecule of interest—a virus or a foreign protein, for example. The sample containing the molecule is first reacted with antibodies (immune-system proteins) tagged with a dye that fluoresces under UV light, and is then viewed under an optical microscope. Since the antibodies can be designed to bind only to the virus or protein, fluorescence under UV light indicates the presence—and often the location and amount—of the substance. "It's an extremely powerful technique," says University of Oregon professor O.



Top: An antibody-labeled rat-tissue cell as seen through a conventional optical microscope. Bottom: A much more detailed photoelectron micrograph of the same cell reveals its intricate interior network of fibers.

Hayes Griffith, one of the PEM's co-developers. Griffith's group is tapping the technology to study cell structure and function at the molecular level.

Just as UV light in sunshine causes only the surface of the skin to tan, so the PEM's UV light dislodges electrons only from the surface of the object. The electrons are accelerated through and focused by a system of electrostatic "lenses" (actually electrical fields) onto a film. The result is a relief view of the object.

"The PEM's resolution is not yet as good as that of the standard electron microscope," says Gertrude Rempfer, professor emerita at Portland State and leader of the team that designed PEM's electrostatic lenses. The reason is that the electrons emitted by the object must be accelerated before passing through the lenses, a process that produces aberrations in the image. Rempfer hopes to solve this problem with new optical systems.

Griffith's team is already applying the PEM to several areas of molecular biology, including the study of cell surfaces and DNA molecules. In addition, the PEM will enable Griffith's group to compare the appearance of a normal cell to one affected by substances called tumor promoters. The result could be a better understanding of how tumor promoters work.

The PEM is also being used to study antibodies—which can be made to attach not only to certain foreign particles, but also to specific sites within a cell—and to study how carcinogens bind to DNA. The researchers have already generated images of the DNA molecule, Griffith says, and "within two years we hope to obtain views of DNA actually binding with carcinogens." Other potential applications include close-up studies of cancer cells and the imaging of molecules binding with cell receptors (special structures on the cell surface that relay chemical signals to the cell interior), which are expected to play a major role in new-drug development (see "Taking the guesswork out of drug design," p. 38).

Griffith concedes that the PEM needs to be refined before it can find its niche in the marketplace. And that niche might not even be in biology, but in electronics—as a nondestructive testing device for microcircuits, for example. "Selling the idea of a new research tool is always hard," says Griffith. "Unless the PEM proves itself with a real breakthrough, it could remain a laboratory curiosity." □

—Darrell E. Ward

A keener ear for ultra sound

Pennsylvania researchers have developed a novel process for making economical and sensitive ultrasound transducers that could eventually lead to a new array of military, industrial, and medical scanners.

Ultrasound devices analyze living

and nonliving material by bouncing high-frequency sound waves, emitted from a transducer, off the object; the returning echoes are picked up by the transducer and converted into an image of the object. The technique is widely used in medical imaging (fetal monitoring, for example), underwater detection, and nondestructive testing to spot internal flaws in such systems as transistors and pipelines.

These transducers make use of piezoelectricity—the conversion of pressure (including acoustical pressure) to electrical signals and vice versa. It is often hard to obtain the right match between the impedance of the transducer material (usually made from a ceramic or from a single crystal of a material such as lead zirconate titanate) and that of the medium through which the sound waves are transmitted. A mismatch results in a serious weakening of the detected signal and a consequent deterioration of resolving power. Furthermore, the limitations of ceramic technology—such as the difficulty of growing large samples with uniform properties and the problems of growing large single crystals—have restricted the number of applications of transducer materials. Yet another problem is that most transducer compunds lose their piezoelectric properties with time.

Researchers at Pennsylvania State University in University Park may have a solution: inexpensive, easily fabricated transducer materials called polar glass-ceramics. "Transducers made of these materials could improve the listening power of ultrasonic scanners and sonar devices," says Arvind Halliyal, research associate directing the Army-sponsored project; the materials' pyroelectric properties (which relate temperature to electricity) could also make them useful as thermal detectors.

Many of the drawbacks of conventional transducer materials are overcome with Halliyal's materials, which could consist of ordinary silicon dioxide melted with inexpensive additives such as barium oxide. The glassy material is heated in a graphite mold to form a piezoelectric glass-ceramic made up of tiny, electrically polarized crystals. The mass maintains its polar characteristics indefinitely, and the crystals can be fabricated into much larger—and thus more sensitive—transducers than are possible with other ceramic materials.

Halliyal declines to speculate too broadly on potential commercial uses. He notes, however, that "the greater sensitivity makes the materials ideal for applications where very low levels of noise must be picked up." For example, the material could help locate fish, find mineral and oil deposits, and track submarines. In fact, the Penn State researchers say their new transducers are more sensitive than conventional submarine hydrophones by an order of magnitude. And since the glass-ceramic functions even at very high temperatures at which other piezoelectrics break down, applications might also include pressure gauges in nuclear or chemical plants and friction-detecting automobile sensors. □

—Hugh Aldersey-Williams

Worker groups ask for VDT rules

Alarmed by potential adverse health effects of video display terminals (VDTs), a coalition of labor groups is pressing state legislators in California, New York, Massachusetts, and at least 10 other states to regulate their use. The proposed laws range from calls for further study to far-reaching legislation that would cover not only the VDT equipment itself but also working hours, break schedules, office layouts, and even management practices.

Fears about VDTs are not new; the federal government has been evaluating their potential hazards for several years. The National Institute for Occupational Safety and Health (NIOSH) identifies three somewhat overlapping areas of concern related to VDT use: radiation from the terminal, dangers to pregnant women, and mental and physical stress. At present, NIOSH maintains, there is no evidence that VDTs pose radiation danger or any risk to fetuses; however, NIOSH researchers claim that improper VDT use could lead to some forms of physical and mental stress, and have suggested corrective guidelines. The most ambitious pending state legislation would make these guidelines mandatory.

But the labor coalition—including the Association of Working Women (also called 9 to 5), Service Employees International Union, the Communications Workers of America (CWA), and the Newspaper Guild—are pressing for legislation that goes beyond the NIOSH guidelines. Citing birth defects and miscarriages among VDT workers, for example, 9 to 5 spokeswoman Deborah Meyer wants to guarantee all pregnant women the right to be assigned non-VDT work. "We simply don't know enough about VDTs' effects on the fetus," says Meyer, "and until we have better information, we should err on the side of safety." The group is now recruiting volunteers for a study, by New York's Mt. Sinai Hospital, of childbearing experiences among 10,000 office workers, half of whom use VDTs. NIOSH plans to begin a similar two-year study, possibly as early as this fall, of 4000 women.

Other health risks have also received inadequate attention, according to CWA's David LeGrand. VDT screens should be electrically grounded, he says, to prevent electrostatic buildup around the screen, which can dry out the skin and cause rashes. He also calls for more research on the effects of magnetic fields and very-low-frequency nonionizing radiation.

Some states have already introduced regulations governing VDTs in state offices. California's procurement guidelines, for example, are very specific with respect to keyboard features, office furniture, and VDT screen characteristics (including size, contrast, brightness, and antiglare features). New Mexico has similar but less detailed guidelines, which also recommend that managers allow workers sufficient breaks and include workers in the planning of VDT implementation. Massachusetts, Colorado, and Wisconsin also have guidelines for VDT use by state employees, as does the District of Columbia for its workers.

California State Senator Bill Greene is sponsoring a bill that would require the state Occupational Safety and Health Administration to develop VDT regulations, within a year, that would apply to all VDT users. New York Assemblyman Frank Barbaro has introduced a bill that would regulate terminals and workstations and would also require a 20-minute break after two hours of work and annual eye exams; the bill would also entitle pregnant women to request a transfer to non-VDT work in some circumstances. The Massachusetts legislature is considering several bills, including a comprehensive proposal by Representative Angelo Scaccia. His bill—which would apply to VDT users in private industry as well as in state offices—includes workstation requirements, eye exams, pregnancy transfers, mandatory breaks, and a five-hour daily limit on VDT work.

But some of the legislation may be in

CBEMA

Office-worker groups are calling for regulation of VDTs in order to prevent adverse health effects. But some management representatives claim that the workers have a much broader agenda, including an overhaul of workplace conditions.

for a tough fight, largely from two groups based in Washington, D.C.—the Computer and Business Equipment Manufacturers Association (CBEMA) and the Center for Office Technology, which includes VDT users and manufacturers. CBEMA president Vico Henriques agrees with NIOSH and the worker groups that improper use of VDT equipment can cause mental and physical stress; however, he maintains that worker education—not regulation—is the most effective means to promote proper working conditions and VDT operation. The association is now issuing pamphlets and other written materials to alert office workers to potential health problems and to offer tips to alleviate VDT-related discomfort.

The industry groups are most upset with legislation that raises issues that have nothing to do with VDTs themselves. "A number of legislative proposals essentially would regulate management philosophy," says CBEMA communications director Charlotte LeGates. For example, bills that would forbid the monitoring of keystrokes "are not really a response to VDT health hazards," she says.

CWA's LeGrand acknowledges that worker safety is not the only issue; there is also the larger concern that managers could use computers to exercise tighter control over workers. "Both industry groups and the labor unions recognize that the underlying issue in the VDT debate is workplace control," he says. "We want legislation that addresses the real cause of stress—office working conditions."

LeGrand concedes that the chances for passage of the most restrictive proposals are slim, particularly during the first year they are introduced. In fact, half a dozen states have already defeated legislation to regulate VDTs, but they are now considering bills that would require investigation of potential health and safety factors. "This is a new issue," says LeGrand, "and we'll have to educate legislators first." □

—Kevin Finneran

A West Point for engineers

Of the 24,000-odd resumes Analogic Inc. in Peabody, Mass., receives every year, company CEO Bernard Gordon finds only a handful of engineers he considers capable of running a project. The rest may have talent and intelligence, he says, but they lack the hands-on problem-solving skills he considers essential to engineering productivity. And, perhaps worst of all, claims Gordon, their university education has done nothing to correct a lack of personal discipline and responsibility in today's culture. "What's needed," he says, "is a leadership academy comparable to the military's West Point."

Gordon, who has complained for decades about modern engineering education and slipping industrial productivity, plans to put his ideas into practice next year. Through a $10 million nonprofit foundation, he is starting the Gordon Institute, a graduate-level leadership school for engineers. Its students will be working engineers chosen by their companies for their leadership potential. The institute, to be based in Wakefield, Mass., will offer a one-year program leading to a master's degree in engineering management.

Noting that Gordon was heavily influenced by his U.S. Navy training, one of the school's trustees says Gordon wants the school to breed "somebody who's going to win. He wants it to be in their gut to attack the problem." That kind of passion, says Gordon, is precisely what U.S. engineers need in order to compete with foreign technology companies.

Gordon, who has founded several successful companies and holds more than 200 patents, maintains that engineering schools encourage elitist attitudes in their students. He believes every young engineer should serve as an apprentice in a company (as he himself did), moving up gradually from the bottom of the organization. He also charges that engineering professors, many of whom lack industry experience, denigrate professional engineering and glorify academic research. Not surprisingly, that contention is disputed by most engineering educators.

Gordon blames industry as well as academe for failing to adequately train engineers in how to be productive. Because the average starting salary of an engineering graduate is about $27,000, he says, most companies think it is a waste of money to apprentice new graduates and instead often assign them to responsible positions for which they are unprepared.

Not all engineering educators bristle at Gordon's criticism of their performance. Gerald Wilson, dean of engineering at MIT and a trustee of the Gordon Institute, views the school as an experiment and hopes it will identify some aspects of leadership that undergraduate education might help develop. "The reason I'm serving there is that I'm not satisfied myself that we are doing everything that can be done," he says, adding, however, that it's impossible for universities to make engineers everything industry wants them to be. The average engineering

undergraduate program comprises 140 credit hours (20 more than undergraduate programs in most other disciplines) and takes 4.6 years to complete, according to the Accreditation Board for Engineering and Technology. Even though "industry likes to complain about our students," Wilson notes, "they beat down the doors here to hire our graduates."

The Gordon Institute's tuition will be $10,000 for the year-long program, but the full cost to employers, most of whom will pay their employees' salaries and benefits, room and board, and other costs, could be as high as $100,000 per student. The school will have an annual operating budget of $1 million, according to Jerome Levy, a former Navy educator who helped Gordon design the institute and serves as its associate dean.

The school will have a full-time faculty of five, including Levy and the institute's dean, Bernard P. Goldsmith. Goldsmith was responsible for graduate programs for executives and engineering managers at Carnegie-Mellon University and also has the prerequisite industrial experience—10 years as a reliability engineer for Raytheon.

The institute plans to supplement the staff with adjunct faculty from nearby universities. Faculty will also be drawn from industry, especially for the advanced technology segment of the curriculum, which will change each year depending on the specialties of the companies sending students to the school.

Although the institute would not release the names of companies planning to send employees, Levy said requests to enroll in the school were so numerous that the size of the first class will be doubled from 20 to 40.

Companies like Acrosystems Corp., which trustee Harold Goldberg heads and which employs only 20 people, can't afford the cost of Gordon's program. And Larry Mayer, manager of industrial relations at Raytheon Laboratories (Bedford, Mass.), says that his company would not send an employee to such a school, "primarily because we have all types of in-house leadership training programs here." But Goldberg points out that other large companies, including General Electric and Siemens of West Germany, believe that Gordon's highly personal brand of engineering leadership training may be worth a try. □ ***—Tammi Harbert***

Earning a degree at your PC

An advanced degree has always been an attractive path to professional achievement. But for most people who work at full-time jobs, going back to school means several hours a week of commuting, class time, and homework on top of an already full workload.

Home study by personal computer teleconferencing might one day change that scenario. College-by-computer is now offered by only a few U.S. schools, and is beset by high costs and a shortage of trained instructors. Still, the convenience of "attending" class at any time of the day from the home or office, or even while traveling, provides a powerful incentive. "I used to spend two hours a day just commuting from work to school to home," says teleconferencing student Brian Smith, corporate communications manager for the Public Service Electric & Gas Company of New Jersey. "Now I log into class from my home computer and put that time into course work." As a result, he was able to increase his class load and finish his master's degree a semester earlier.

Convenience isn't the only advantage. Since students can edit their comments before sending them in, they are better prepared than when they simply speak up in class. They thus tend to participate more equally and more often, says Paul Levinson, director of Connected Education (New York), the nonprofit computer-conferencing organization that runs the teleconferencing courses at the New School for Social Research (New York).

Teleconference participants communicate on line with each other via modems from a PC. They can also leave messages for each other, which are stored chronologically in a central computer file. The link between the PC and the central computer is made through regular phone lines or through economical packet-switching networks such as Tymnet and Telenet.

Only two U.S. schools now offer graduate-level teleconference courses: the New School and the Western Behavioral Sciences Institute (WBSI) in La Jolla, Cal. The New York Institute of Technology in Central Islip offers undergraduate teleconference courses, however, and several schools—including the New Jersey Institute of Technology (NJIT) in Newark and the University of Michigan in Ann Arbor—offer such sessions as an adjunct to face-to-face classes. Course requirements include a computer, a modem, and communications software; WBSI requires students to use software that runs only on DEC Rainbows, IBM PCs, and IBM-compatible equipment.

At the New School, only the media studies department has sponsored teleconference courses; other divisions—especially business and management studies—are expected to offer courses early next year. Meanwhile, WBSI offers senior executives a two-year certificate in management and strategic studies, consisting of four six-month sessions on national and international topics of importance to managers.

Schools offering teleconference courses either buy their own computer and software or lease space on an existing system. The oldest such network is the Educational Information Exchange System, created by Murray Turoff, NJIT professor of computer science. Both Connected Education and WBSI lease space on the network.

But classroom teleconferencing still faces a few hurdles. Some people balk at trading face-to-face dialogue for an impersonal computer screen. Furthermore, instructors can't be sure who is actually "sitting in" on the class or taking an exam, and they must often devise new teaching methods, since they are deprived of such cues as restlessness and glazed eyes to know when students don't understand.

Cost is another factor. WBSI's two-year program costs $25,000 for tuition, hardware and software, and computer time, according to president Richard Farson. Nevertheless, the cost is lower than for many conventional degree programs; tuition alone for a one-year master's program at MIT's Sloan School of Management is $26,600. And because the students take classes at their convenience, they can earn a steady salary at the same time.

Most advocates aren't discouraged by teleconferencing's slow acceptance in education. For many of them, it's simply another reason to get out and spread the word. For example, New England Commons (Waltham, Mass.) plans to introduce a management education program similar to WBSI's. Says Robert McAndrews, president of New England Commons: "When I tell people in education about the technology, they're interested. They just hadn't heard of it—yet." □ ***—Margie Ploch***

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National Education Assn., 1201 16th St., NW, Wash., DC 20036, (202) 833–4000.

International Council for Computers in Education, Univ. of Oregon, 1787 Agate St., Eugene, OR 97403, (503) 686–4414.

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TECHSTARTS

Bipolar Integrated Technology:
SPEEDY CHIPS THAT KEEP THEIR COOL

In the contest for the fastest microchips, devices based on a semiconductor technology known as bipolar win in the silicon category. But bipolar devices get so hot that just a small number of circuits can quickly overheat conventional chip-packaging materials. Bipolar Integrated Technology (BIT) has developed a proprietary process that reduces the area of individual bipolar transistors; with less heat dissipated, cooler-running circuits result. And because the company can put more of these circuits into conventional packages without overheating, it can now use bipolar technology in such complex applications as seismic analysis, high-resolution graphics, and digital signal processing of radar and sonar beams—all of which depend on very fast operation. Companies already making chips for these markets but using other technologies include Intel and Advanced Micro Devices.

Financing: $9.8 million in venture capital from corporate investors Analog Devices and Raytheon and from venture capital firms including Inter-Ven Partners, BancBoston Ventures, Union Venture, the Republic Venture Group, and Harvard Management.

BIT is making denser, more complex bipolar chips than previously possible, claims company president George Wilson.

Management: The three technical founders, George Wilson (president), Kenneth Schlotzhauer (VP of engineering), and James Pickett (VP of manufacturing), came from Tektronix's integrated circuit division, where Wilson headed overall design, Schlotzhauer managed bipolar design, and Pickett managed the processing lab. The other founders are Kenneth Giles, VP of finance, who held the same title at publishing firm Columbian, and Les Soltesz, VP of marketing, who was a marketing manager at Intel.

Location: 1050 NW Compton Dr., Beaverton, OR 97006, (503) 629–5490.

Founded: July 1983.

MultiLink:
GROUP MEETINGS OVER THE PHONE

Conference calls—which allow several people to participate in a single phone call—have become commonplace in business, especially in companies that have sophisticated interoffice phone systems. But MultiLink has taken the concept to a new level, enabling as many as 50 callers using ordinary office or home phones to take part in one call. At a predetermined time, participants call a MultiLink office, where an operator connects them together, using the company's special switching equipment. In addition to providing this service (for which MultiLink charges by the minute), the company also sells equipment—targeting local phone companies with its large-capacity switches, and private businesses with smaller versions. It also sells equipment for adding freeze-frame video and interactive computer graphics to telephone meetings. In the market for conference-call services, MultiLink competes primarily with AT&T; in the equipment market, its competitors are makers of teleconferencing systems such as Colorado Video.

Financing: Approximately $1 million from Arthur D. Little Limited Partnership.

Management: Dwight J. Grader, cofounder and president, was president of PPM Construction, a real estate development and construction firm. John J. Hassett, cofounder and VP of sales and marketing, was VP of sales and marketing for Multicom, a telecommunications firm. John Harrison, VP of engineering, was a consultant in telephony and microprocessor design.

Location: One Market St., Lynn, MA 01901, (617) 595–7577.

Founded: May 1985.

Automation Technology Products:
LINKING DESIGN AND PRODUCTION

In recognition that makers of mechanical systems have lagged behind electronics manufacturers in tying engineering design into other automated production activities, Automation Technology Products is developing computer-aided engineering and design software specifically for mechanical products. Its system integrates initial engineering analysis with subsequent solid modeling, structural analysis, tooling development, and work-flow design. The company's initial target markets include such mechanical-intensive industries as aerospace and automobiles. Its chief competition comes from makers of comprehensive lines of factory automation equipment such as McDonnell Douglas and General Electric, which are beginning to address the engineering-design phase of production.

Financing: $12 million in venture capital from investors including Arthur Rock, Hambrecht & Quist, the Mayfield Fund, Mohr Ventures, Schroder Venture Managers, U.S. Venture Partners, Merrill Pickard Anderson & Eyre, F. Eberstadt & Co., Montgomery Bridge Fund, and Security Pacific Capital.

Management: Robert Benders (founder and president) and Lemuel Bishop (VP of finance) came from General Electric's CAD subsidiary Calma, where Benders was president and Bishop was VP of finance. John Benbow (VP of research) headed project management services for British computer maker International Computers.

Location: 1671 Dell Ave., Campbell, CA 95008, (408) 370–4000.

Founded: April 1983.

T1 PHONE LINES SPUR EQUIPMENT MARKET

By 1990, sales of high-speed multiplexers should quadruple

Businesses are increasingly turning to a variety of alternatives to public telephone networks for transmitting voice and data at high speeds. Whatever the transmission medium, multiplexers are required at the customer's premises to channel multiple, lower-speed voice and data message streams into and out of the carrier at the proper rate for high-speed communications—generally 1.5 megabits per second (known as the T1 rate).

The market for such devices is currently small, with 1985 U.S. revenues at $125 million, according to Technology Financial Services (Chelmsford, Mass.). But by 1990, it is expected that the growing need for such equipment will push sales to $500 million.

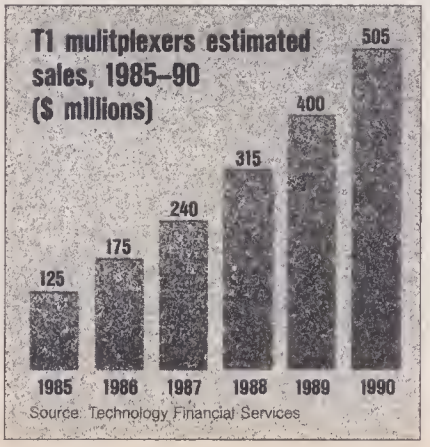
Most of the current market for high-speed multiplexers is tied to the commercial use of dedicated T1 telephone circuits. AT&T first offered T1 private-line service to customers in 1977, but the service has only taken off since 1983, growing from under 10,000 installed local and long-distance circuits to approximately 50,000. This increase was stimulated by AT&T's reduction of the cost of leasing T1 lines and by the efforts of the divested Bell companies to support local-exchange connections to nationwide T1 service (a task previously performed by AT&T).

The cost advantages of T1 circuits also aid multiplexer sales. A single T1 line operating over networks of under 200 miles is cheaper than 12 lower-speed phone lines and can carry twice as many voice circuits. New multiplexer technology should allow customers to send even more voice and data traffic over the same T1 facilities and provide more ancillary features, particularly the ability to switch transmissions to a number of alternative destinations (traditional multiplexers operate only point to point).

Several dozen vendors now offer T1 multiplexers. Of these, two public firms—Timeplex (Woodcliff Lake, N.J.) and General Datacomm Industries (Middlebury, Conn.)—hold particular promise for investors.

Timeplex (NYSE: TIX) is a leading producer of data communications equipment, including multiplexers, modems, and network management systems. Its T1 products, accounting for 50% of the company's revenues, have given it the largest share (40%) of the market. Timeplex's rise to prominence is based on the Link/1, one of the first multiplexers to offer network management capabilities and alternate routing in case of linkage failure. The company has continued to capitalize on its lead with heavy R&D spending (some $12 million a year) and by opening new markets for its products. The Link/1 was originally targeted at large corporate data communications systems; a newer switching multiplexer is being marketed for use with both data and voice networks.

The company's estimated 1986 revenues are $120 million, with a profit of $10 million and $1.12 earnings per share. Revenues last year were $96 million, while profits were $10 million and earnings per share were $1.02 (plus 13¢ due to a $1.1 million nonrecurring tax windfall). Profits remained the same between the two years because the company accelerated its product development efforts.



General Datacomm Industries (NYSE: GDC) is the second largest supplier of T1 multiplexers, which provide 20% of its revenues. The firm's traditional strengths have been in supplying multiplexers for internal use by telephone companies and providing a range of data communications equipment to Fortune 500 companies. General Datacomm's initial entry into the commercial T1 market, the Megamux, has been overtaken by competitors' products offering new technology and more features. But the company has improved its prospects by introducing a version with advanced software features, such as the ability to remotely locate points of failure in a T1 network, and by establishing an agreement with **Cohesive Network** (Los Gatos, Cal.) to distribute this start-up's line of switching multiplexers.

The computer industry slowdown hurt sales in the company's general product lines, resulting in layoffs and a drop in profits over the past two years; but an improvement is already evident in the first half of fiscal 1986 compared with the latter half of 1985. Revenues increased from $145 million in 1984 to $184 million last year, while profits dipped from $11.3 million to $10.8 million, and earnings per share fell from 80¢ to 71¢ because of a rise in shares outstanding.

In addition to Cohesive Network, investors should keep an eye on **Network Equipment Technologies** (Redwood City, Cal.), a private company that is one of the fastest-growing firms in the industry. NET offers a well-received T1 switching multiplexer that also provides significant protection against network failures. **Tellabs** (Lisle, Ill.), a publicly traded firm (OTC: TLAB), is of interest because it supplies multiplexers to AT&T for commercial sales. Although only 10% of Tellabs' 1985 revenues came from T1 products, this proportion should grow; the AT&T connection gives Tellabs an extensive nationwide distribution system. □

by John Gantz and David Rosen

John Gantz is executive VP and David Rosen is senior telecommunications analyst at Technology Financial Services (Chelmsford, Mass.), a high technology market research firm.

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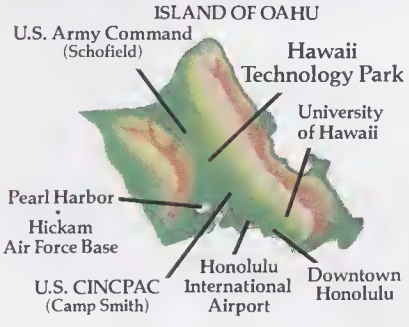

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